CPE Comments and Topics

How to face facts

AFTER a timely interval in which to shake Frankfurt's dust off our feet, we are now in a better position to appraise ACHEMA 1961 quite cold-bloodedly. As reported more fully on page 358 of this issue, the initial impact of this chemical plant exhibition was quite overwhelming. A closer scrutiny of exhibits revealed that remarkably few new developments were, in fact, being shown; progress in this vast field can hardly be expected to adapt itself to a three-year exhibition cycle. Therefore, only when regarding this exhibition as a shop window of chemical plant and processes, will the astounding achievement of the European chemical industry fall sharply into perspective.

It has been fashionable to talk about an economic polarisation of the world into the United States and the Soviet Union, with Europe as a poor runner-up. The inaccuracy of this premise is easily demonstrable to any student of present-day European affluence. Such affluence can be attributed in no small measure to Europe's devotion to applied chemistry since the early 19th century. Yet we gained the uncanny feeling in Frankfurt that, despite itself, ACHEMA stressed German superiority within Europe. Naturally, any international exhibition held in one country will always have a preponderance of local national exhibitors. None the less, even if this is taken into account, Germany's stature in the international chemical industry would still seem analogous to an Everest set in the midst of the Himalayan range. Why is the German chemical industry so impressive?

Many learned tomes have been written to interpret Germany's economic miracle since 1945. The reason for this miracle is probably due to a combination of diligence and hard work, with the additional advantage that much of Germany's industry was totally destroyed after the war. In this way many plants had to be rebuilt from anew, thus giving considerable scope to modern planning and design methods. This was brought out at ACHEMA by the preponderance of chemical plant fabricated in plastics. Where we in the U.K. still talk about the advantage of, for example, fume extractors in polypropylene, or large storage tanks in PVC, the Germans are using them as commonly as similar plant made in stainless steel. A German manufacturer actually related that junior engineers in industry were encouraged by their directors to substitute existing plant in metal for plastics—in this way, they are informed, can the advantages of plastics be properly assessed. This does not happen in our country as yet!

The British chemical plant industry has no need to hide its head in shame; British superiority in many spheres of plant design and fabrication is still acknowledged—even by the Germans. What we must learn from the Germans, however, is that spirit of enterprise and sense of devotion with which engineers, at all levels of the industrial ladder are applying themselves to their particular tasks. The enthusiasm of younger people who visited ACHEMA was quite infectious; groups of German students roamed round the exhibition halls and examined everything most meticulously.

Only by Britain's entry into the Common Market can this keen sense of competition and enterprise percolate through to our own industrial executives. Perhaps the most prominent lesson that could be learned from ACHEMA is that, without British participation in the Common Market, Germany will dominate the European chemical industry, but with Britain participating fully in a European community our chemical industry can only profit by the increasing quality competition from Europe.

No shortage of chemical engineers?

THE 1960 annual report of the British Chemical Plant Manufacturers Association reported that, according to official estimates, expenditure by the British chemical and allied industries during the year was somewhat less than in 1959 and substantially below the 1957 and 1958 levels. However, many important projects were announced, which will mean additional business for the members in 1961 and after.

A most astounding revelation was made in the report in connection with the training and education of chemical engineers. The B.C.P.M.A. was invited by the Institution of Chemical Engineers to comment on a memorandum on chemical engineering manpower and to express a view on the supply and quality of chemical engineers for the chemical plant industry. This request arose because official statistics in the 1959 report of the Committee on Scientific Manpower revealed that during 1956-58 rather more honours graduates in chemical engineering were trained than were needed for industry.

A cross-section of members reported on this that they were not experiencing any real shortage of chemical engineers. On the whole, what was required was both the more mathematically trained and the practical type of chemical engineer, the emphasis being on the latter. In general it was felt that chemical engineers from British universities were well equipped but needed some industrial training before they could become really useful.

It is interesting to compare this statement with other findings that there are at present too many departments of chemical engineering at universities and technical colleges and too few students to fill them. In fact,

we seem to be reaching a crisis in chemical engineering education. Those who decried the abject lack of chemical engineering training facilities 10 years ago have now been altogether satisfied. It is to be hoped that we do not arrive at a point where, on the one hand, too few people take advantage of these facilities and, on the other hand, those who are trained as chemical engineers can find no outlet in an industry that does still not appreciate sufficiently the usefulness of the chemical engineering mentality.

Uranium—non-nuclear applications

NOBODY in Canada can deny the state of crisis that was created last year when the U.S. Atomic Energy Commission decided not to exercise its options to purchase additional quantities of Canadian uranium after expiry of the sales contracts in 1962 (Canada produces some 13,000 tons p.a. uranium). This cancellation considerably dampened the enthusiasm that every Canadian felt for this ' material of the future '. In order to keep the uranium mining industry alive, it was decided to instigate some basic research to develop alternative ' non-nuclear ' uses for uranium.

Consequently, at the end of 1960, the Canadian Uranium Research Foundation was formed, with Prof. F. A. Forward of the University of British Colombia as director of research. Prof. Forward considers that uranium now faces similar exigencies as another Canadian metal, nickel, after the first world war. Up to then nickel's sole application was in armour plating. Subsequent to that, research initiated by the International Nickel Co. developed new products requiring nickel as, for example, nickel stainless steels.

It is felt that the industrial utilisation of uranium and its compounds will depend largely on additions of relatively minor amounts of uranium to improve the properties of other materials. For example, in metallurgy, the pronounced tendency of uranium to form compounds with nitrogen, oxygen, carbon and other elements can be exploited either to remove undesirable components or to improve distribution of others. It has also been predicted that uranium may be useful in promoting carbon nodule formation in iron, as against the plate form present in cast iron. Uranium dioxide may also be valuable in hardening high-temperature alloys and, since little is known of the behaviour of uranium towards phosphorus in molten metals, some further thought may well yield interesting results. In the non-ferrous field, uranium could be used effectively in high-density alloys. For example, there are strong indications that certain combinations of uranium with molybdenum and niobium are unusually corrosion-resistant.

Uranium dioxide has also had extensive use as high-temperature refractory material and it may well be that the addition of uranium dioxide compounds has a beneficial effect on the properties of the more common refractories. The potential uses of uranium as catalysts are also numerous, but although a few patents have been granted for such uses, the field is still relatively unexplored.

East comes West

AS we go to press the Soviet Exhibition is opening at Earls Court, London. Staged as a ' return match ' for the very successful British Trade Fair in Moscow last May, this three-week exhibition promises to be quite different from an ordinary trade fair. The vast expanse of Earls Court has been completely redesigned to accommodate the 22 halls which are meant to represent the various activities of the Soviet economy. The fact that over £1 million was spent on this exhibition is sufficient evidence of the importance that the Soviet government is attaching to acquainting the British people with achievements of contemporary Soviet science and technology and to establish closer trade links between our two countries.

It is still rather difficult, after having walked through all the 22 halls, to obtain an accurate picture of the ordinary rate of Soviet industrialisation. Having seen models of very impressive-looking nuclear power stations, it would be interesting to know what percentage of total electrical output in the Soviet Union is nuclear generated and what peculiar difficulties were associated with establishing nuclear power stations. Other questions to which we, in the West, would dearly like to have an answer are whether the Soviet boiling-water and sodium-cooled reactors are for export and how they would compete on a cost and delivery time basis with British reactors.

By and large, however, the exhibition is most stimulating and informative and should do much to increase trade and exchange of technical know-how between the U.K. and the Soviet Union.

Boiler flue gases

THOSE concerned with the design and operation of water tube boilers are all too familiar with the external fouling and corrosion resulting from certain active gaseous and particulate constituents of flue gases. The need for establishing suitable techniques for the rapid assessment of potential difficulties from these causes, with a given boiler, fuel or method of operation, has long been felt.

The Boiler Availability Committee has recently published a bulletin on ' Testing Techniques for Determining the Corrosive and Fouling Tendencies of Boiler Flue Gases ', which provides details of suitable methods. To ensure that results are comparable, sufficient details are given to enable recommended techniques—some of which were originally developed by the committee—to be applied successfully without reference to other sources.

Testing methods are divided into two main groups. First there are techniques for investigating low-temperature corrosion and its causes (meters for measuring ' acid dewpoint ' temperature, corrosion probes, instruments for determining sulphur dioxide and sulphur trioxide, and ' acid-deposition ' probes). The second group comprises techniques designed for the determination of the nature and extent of high-temperature fouling (probes for measuring the rates of deposition of various constituents of fuel ash).

All methods are necessarily based on the insertion of one or a number of probes. The bulletin does, however, contain many useful hints on correct sampling techniques to achieve the maximum degree of accuracy at reasonable cost in time and equipment. Most of the techniques described are intended for tests of short duration, being designed to yield results within the hour. Such tests are ideal for the detailed investigation of rapid changes in boiler conditions. They are thus better suited for the comparison of different methods of boiler operation or variations in fuel characteristics than for the precise prediction of the period of trouble-free service likely to be obtained from a given component.

An important consideration has been that the testing techniques discussed should not involve an excessive demand for highly trained technical staff. It is, of course, necessary for an experienced technologist to be in charge of a test programme, but, given adequate supervision, non-technical personnel, after a brief period of instruction, can make up the investigating team.

Scientists' Who's Who

EIGHT years ago Leonard Hill Ltd. published 'Who's Who in British Science', the first directory of its kind. The names of over 3,000 leading scientists, with their personal and professional particulars, appeared in this unique book. It is now sold out and the publishers are regularly asked when the next edition will appear. The answer is that it is unlikely to appear again as a purely private venture because it is too costly to produce at the price people are prepared to pay for it.

A directory of this kind is disproportionately expensive to produce because of the enormous amount of detailed labour it requires. Questionnaires have to be sent to thousands of scientists and it may be months or even a year before they are returned. The questionnaires have to be edited and then a proof of each entry has to be submitted to the person concerned. Corrections are usually prolific because personal details such as address, appointment, scientific honours, etc., can change considerably in a period of months. Not until every proof is returned and every correction made can the directory appear.

'Who's Who in British Science' is a directory that is genuinely needed. It is of immense value to our scientists, universities, industries, educational authorities, ministries and the press, and it is consulted regularly in underdeveloped countries seeking scientific and technical assistance. In this respect it helps to ensure that British scientists and British industry are not overlooked. There are repeated demands for a new edition, but it is simply not commercially feasible for a private publisher to undertake.

Leonard Hill Ltd. are prepared to collaborate with those willing to provide financial aid for the production of a new and larger edition. Learned societies, industrial firms, the universities and government departments might well consider how they could help this urgently needed enterprise. It should prove possible to make financial arrangements to launch a second edition and succeeding editions on a regular basis. Individuals and organisations prepared to take an interest in 'Who's Who in British Science' are invited to communicate with Leonard Hill Ltd., Leonard Hill House, Eden Street, London, N.W.1.

Petroleum in the United States

THERE has been a noticeable trend in American refining towards fewer plant with larger capacity. Figures recently given by H. Perry in a paper presented to the Institute of Fuel point out that from 1950 to 1959 the number of refineries declined from 367 to 313, whilst the crude oil distillation capacity increased from 6½ million bbl./day to almost 10 million bbl./day. Unlike Europe, the principal petroleum product in the U.S. is still gasoline. In 1959 it amounted to 44% of all finished products. It is anticipated by Perry that gasoline will remain the main product for many years to come, and that demand for distillate fuels will increase and the proportion of residual fuels will continue to decline.

The sales pattern in the American petrochemicals industry is most interesting. Historically, the petrochemicals industry started as an adjunct to refineries and gasoline plants. Since 1945 there have been three distinct phases of development of petrochemical plant. First came the aliphatic chemical developments with plants to synthesise such organic chemicals as alcohols, esters and glycols. The second phase occurred in the early 1950s when there was a rapid expansion of plants to produce inorganic petrochemicals such as ammonia, sulphur and carbon black. The last phase, during the past five years, has been to produce aromatics such as benzene, toluene and xylene. In 1959, 29% of the total chemicals produced in the U.S. originated from petroleum and natural gas.

In order to improve petroleum refining techniques, much basic research is carried out by the U.S. Government on petroleum problems. The three government agencies which conduct scientific research in this field are the National Bureau of Standards of the Department of Commerce, the Geological Survey, and the Bureau of Mines of the Department of the Interior. The National Bureau of Standards is concerned primarily with standardisation, preparation of specifications, and basic and applied research on products. The Geological Survey is more concerned with topographic mapping and stratigraphical studies which are of great assistance to the petrochemical industry. The Bureau of Mines conducts basic and applied research on production, storage, processing and utilisation programmes. In addition, this department conducts an important research programme on oil-shale design to develop the scientific knowledge required to initiate an oil-shale industry when it is needed in the U.S. The extensive deposits of oil-shale make this a most important potential raw material—it must be remembered that considerable experience has been gained by the Russians in working one of their large oil-shale deposits in Estonia.

New developments in plastics

INTERPLAS continues to flourish to such an extent that British plastics companies feel they can hardly afford not to exhibit there, especially because of the large number of foreign buyers that particularly come to London for this event. Yet, in going round the last Interplas Exhibition, we gained the impression that very few new developments had occurred since the 1959 exhibition.

New developments in the plastics industry fall into three main groups. Firstly, developments of an entirely new polymer (polypropylene and *Delrin*, for example, have been developed and marketed during the last five years). Secondly, development of a new polymer range (for example, PVC with an altered molecular weight or a new range of diols for polyurethane foam). Thirdly, new applications for already well-established plastics (laminating PVC with reinforced plastics to fabricate chemically-resistant tanks having considerable mechanical strength). Most of the new developments at Interplas belonged to the third group and were therefore very much a variation on a not-so-original theme.

Plastics fabricating machinery, however, seems to become more automated and remote-controlled. The type of machinery required in injection moulding or blow moulding is fabulously expensive and its price is increasing steadily (unlike the price of plastics raw material which tends to decrease). It is rather a pity that so little basic work has been, and is currently being, devoted to basic studies of plastics fabricating plant. Unfortunately, this field is still an entirely empirical art and will continue to remain so until chemical engineers and plastics technologists consider it worthy of combined investigations.

Advances in gas-cooled reactors

NEARLY two-thirds of the world's nuclear plant capacity is gas-cooled graphite-moderated plant. This figure was given by C. L. Rickard at the American Power Conference held in Chicago recently. The reason for this fact is to a large extent due to the extensive gas-cooling programmes of the U.K. and France and, in addition, the gas-cooled nuclear power stations which are being built in Italy, Japan, Germany and the United States.

The world-wide emphasis on gas-cooled reactor systems, according to Rickard is due to the degree to which gas cooling helps to satisfy major criteria for the attainment of competitive nuclear power, which are:

(1) Production of high-temperature, high-pressure steam in order to take full advantage of present-day high-efficiency turbine generators.

(2) High fuel burn-up and long fuel life as a means of reducing fuel costs and dependence on fuel re-processing.

(3) High power density in the reactor core to achieve compactness and reduce capital costs.

For the large-scale high-temperature gas-cooled reactors to be built in the U.S. during the next few years, net plant efficiencies of 40% have been forecast. Besides this there has been a significant improvement in fuel burn-up from about 3,000 MW days/ton nuclear fuel for the Calder Hall type reactor to approximately 70,000 MW days/ton for the advanced high-temperature gas-cooled reactor.

According to Rickard high fuel burn-up and efficient use of neutrons in the nuclear chain reaction of the high-temperature gas-cooled reactor means reduced fuel costs. Newer types of fuel elements will enable the core to operate at temperatures in excess of 2,000°F., resulting in steam conditions of 1,450 p.s.i and 1,000°F. The inert nature of the helium gas coolant, relatively low pressures in the reactor and specially designed flow paths will permit maximum use of comparatively inexpensive materials of construction. These comments certainly indicate that there is a considerable future in gas-cooled graphite-moderated reactor on which this country has staked her nuclear future and reputation.

How to solve a problem

AN apocryphal story was related by Prof. Fairbrother when opening the new technical unit at J. Crosfield & Sons last month. There was a competition between a chemist, a physicist, an engineer and an administrator as to who could best determine the height of a neighbouring church tower situated close to the university. To carry out this project each of them was supplied with a sensitive aneroid barometer.

The chemist approached the tower and measured the pressure on the floor, then climbed to the top of the tower and measured the pressure again. From the difference in pressure he worked out what the height ought to be. The engineer tackled the project by tying his aneroid barometer to a piece of string, dangled it over the side of the tower and made an appropriate mark on the string. He then went downstairs and measured the length of the string. The physicist was firmly convinced, as all physicists are, that an experiment should only be carried out once, regardless of the cost of apparatus; he thereupon took a stop-watch out of his pocket, threw the aneroid barometer over the side and tried to time the rate of fall. Finally the administrator simply took his aneroid barometer inside the church, found the resident verger and exchanged the aneroid barometer for the height of the tower.

Which approach, we wonder, was (*a*) the most accurate and (*b*) the most elegant. Surely the administrator must be awarded full marks for accuracy—since he relied on empirical evidence. The physicist's approach was probably the most elegant, although it had the disadvantage of being somewhat destructive.

The moral of this tale (if there is any moral) is probably that, if these four gentlemen were ever to attempt to carry out this project on a committee, nothing positive could be achieved and the cost in frustration, stop-watches, etc., would soon become prohibitive.

An instrument store at one of the offices of N.I.F.E.S.

Fuel Efficiency in the Chemical Industry

By W. Short,* B.Sc., M.Inst.F.

Nowadays, when keen competition in chemical processing makes it vital to utilise fully all the by-products obtained, it is still not sufficiently appreciated that much money is senselessly wasted by paying too little attention to fuel efficiency. This does not necessarily imply that only the most modern steam-raising plant must be installed, as this article points out. Closer attention, devoted to properly utilising the available heat capacity in process steam can result in very spectacular savings. Several actual case histories are quoted to illustrate this point.

THE materials used in chemical processes are usually fairly expensive and, at most firms, particular care is taken by the production side to reduce wastage to a minimum. However, there is sometimes a tendency to treat the heat and power requirements of the process as a ' service ' which is provided by other people for the benefit of production. On the other hand, the engineer responsible for steam, power and services may find that his authority stops when his steam mains or power cables enter process departments. Consequently, there is sometimes a ' region of confusion ' where losses occur, suspected by the one side but unappreciated by the other.

Often work of the National Industrial Fuel Efficiency Service has consisted largely of acting as a clearing house of information, and immediate savings or improvements in production were obtained by applying existing knowledge from one side to the problems of the other. For example, at one firm the services engineer was always surprised at the steam used by one department, but the production side felt that they were taking every care in the use of this steam on their heat exchanger. Eventually it was found that nearly 2,000 lb./hr. of steam were wasted by being passed through heating coils in a large range of old storage tanks which were no longer in use.

Developing this theme a little further, at two separate firms the central boiler plant was kept in ideal condition, with excellent maintenance and very good combustion conditions. However, only a few hundred feet away was a series of direct-fired pots and stills, and tests showed that the oil burners on these were giving very poor results indeed. They were not under the control of the services engineer who supervised the boiler house, and maintenance had been neglected over a long period so that burner nozzles were worn and some air dampers could not be moved. In addition, production operatives did not understand how to adjust the burners to get optimum conditions.

At one firm, improvements, following careful tests, produced a saving of £2,300 a year and cured a smoke nuisance. At another firm savings exceeded £5,000 a year, and the time to process each batch was cut by 10%.

Now the previous examples may

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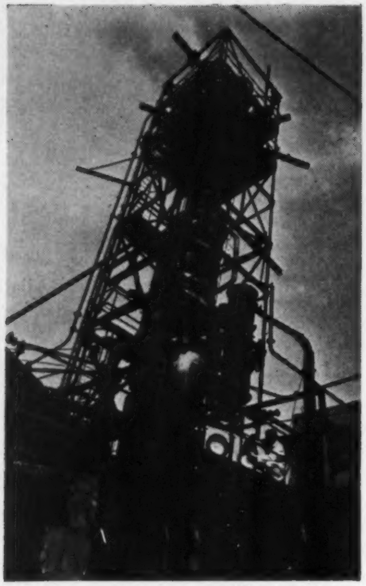


[Courtesy: N.I.F.E.S.

Measuring steam to a refining still and its ancillary equipment

seem to show a complete lack of communication between departments in a firm and it can only be repeated that this state of affairs regrettably does exist at a large number of firms and is not confined to the chemical industry. Of course, at many other firms good co-operation exists between services and production, but lack of time may prevent detailed examinations and tests being carried out to determine whether the practical and theoretical heat requirements of a process agree reasonably well. It often happens that individual steam users are not metered and, even at quite large firms, steam meters are often installed on a department basis to enable an allocation of steam costs to be made, and it is not really possible to measure an individual still or pan.

Even with departmental metering, intelligent interpretation of steam usage against production may give some clues to show that further investigation is necessary. In one department it was found that about 30% of the steam was being used to heat the jacketed lines through which the materials used in process, and the final product, were transferred from one part of the process to another and to the final storage tanks. Considerable alterations took place: improving insulation, eliminating some long and tortuous runs of pipe and long leads to the traps, in which unnecessary condensation occurred, and by stopping some steam leaks. Some product lines were regraded so that they would drain into tanks or process vessels, and this enabled the steam to the jackets on these lines to be shut off except for about half an hour of preheating before each batch was transferred. The result of all these alterations was a saving of 25% of the previous departmental usage.

Steam wastage

Evaporation or concentration processes occur at many chemical firms and these are fruitful sources for savings or increases in production following detailed plant tests. First of all, points which seem obvious but are sometimes neglected, should be eliminated. Air venting of steam coils or heaters is vital and manual arrangements are rarely satisfactory. Either the vents are open too much, causing steam wastage, or left closed so that air cannot escape and production is impaired. Automatic air vents are better, but these must be correctly sited and should be frequently checked to ensure they are still working properly. Trapping of the condensed steam should also receive attention. Modern traps, correctly selected for the application, are reliable for quite a long period after installation, but do need periodic maintenance and checking. If condensate flows to waste, which, of course, is bad because useful heat is wasted, a faulty trap may be detected by the extra steam blowing out of the discharge pipe. However, many firms realise the value of the hot condensate, which is usually very pure water, and they recover it by a collecting system. This may mask the passage of steam through a trap and, particularly with large steam consumers, it is advisable to fit a by-pass arrangement so that the condensate can be discharged to an open drain for a few minutes each week and the trap's behaviour checked. Many types of trap will discharge the condensate virtually at steam pressure, and temperature and 'flash' steam will be formed as soon as the pressure is reduced. If the heater or vessel being checked is under an appreciable pressure, the volume of this flash steam may be considerable, but careful study may enable an observer to distinguish between this, which is always accompanied by condensate, and the steady blowing of uncondensed steam when little condensate is passing.

One large chemical firm has adopted a maintenance system for its traps which consists of the removal of major traps at monthly intervals and small traps at quarterly intervals. To start the scheme, traps were gradually replaced where necessary until only a few standard types and sizes were used and every size was mounted between isolating valves with by-pass arrangements and standard distances between flanges or unions. It was then only necessary to carry about 20 spare traps, one of which could be issued at the periodic changes to replace the trap in service. This was cleaned and replacement parts fitted when necessary. It was then connected to a convenient test point, actually one of the drains from the steam main leaving the boiler house, so that its operation could be checked, and was put into store until required for the next change-round.

Undiscovered steam losses

As an example of the large losses that can occur without being discovered, one firm had an evaporator, utilising an external steam heat ex-

Table 1

	£
Cost of 3,500-lb./hr. boiler, boiler house, etc.	11,200
Stage 1	
Two tanks, supporting framework, foundations and erection ..	650
Insulation of tanks	150
Steam coils in tanks, pipework	200
Two thermostatic steam valves, strainers and check valves	75
Float switches, by-passes, throttling valves, etc., traps	125
	£12,400
Stage 2	
Heat exchanger	600
Thermostat valve for cold water, strainer, check valve	60
Sigmund pump (actually capable of up to 2,300 gal./hr.), float switch, starter	65
Extensions to sump, builder work, etc.	400
Additional water piping	50
	£1,175
	£13,575

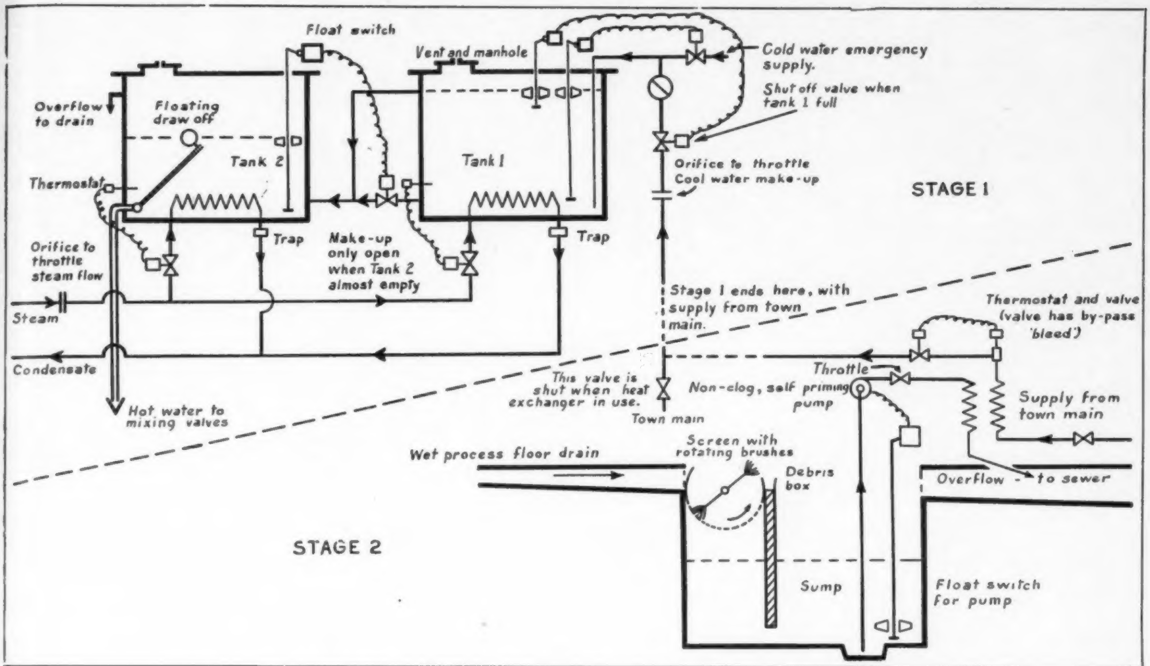


Fig. 1. Scheme for hot-water storage coupled with an effluent heat exchanger as a second stage

changer, which was trapped and the condensate returned to a large collecting main. When a detailed test was made on the evaporator, the heat balance showed that over 35% of the inlet steam could not be accounted for, either as useful work or radiation losses from hot surfaces. Checks showed that of 8,000 lb./hr. of steam metered to the unit, just over 3,000 lb./hr. were blowing through the trap into the collecting main. The flow of water in the main collected from other points was sufficient to condense all this steam, so that none was visible at the discharge point. As very little of the collected water was re-used because of site problems, the higher temperature was of no real value. A new trap cured the problem, giving a financial saving equal to its cost every week. The firm did not have individual steam meters on the lines to every item which might have enabled them to see the rise in steam usage of the evaporator. In fact, continuous metering of every vessel is a very expensive item both in capital outlay, maintenance and the taking of regular charts or readings. However, it should be possible to install a metering point, such as an orifice or pitot tube with connecting points on every steam line, so that occasional checks can be made either by using a single meter or, possibly, by having a complete check made at intervals using an organisation such as N.I.F.E.S. to provide a large number of meters and the staff to install them and interpret the results.

Process survey

In many cases N.I.F.E.S. has been asked to carry out a survey of a process to advise on the size of possible new boilers, since the present plant was hard pressed to meet demand, only to show that existing plant was easily able to meet the true load if waste were eliminated and correct use made of any hot vapours or effluents as sources of heat.

If a firm uses large quantities of hot water and allows hot vapour or effluent to go to waste, it can almost always be shown that a spray condenser or heat exchanger will be a very attractive financial proposition. There is such a range of equipment available that any vapour or liquid can be handled without contamination or corrosion troubles. A striking example recently encountered was that of a firm at which the main process really consisted of washing large batches of material with water at various temperatures from 110° to 150°F. Some chemicals were, of course, used to remove certain impurities, but these did not affect the problem. A new boiler plant was needed and the firm felt that a boiler rated at 10,000 lb./hr. of steam, costing about £20,000, including boiler house and all auxiliaries, would be necessary to deal with the peak loads occurring when hot water was supplied to the vessels using conventional steam/water mixing valves. When the various quantities and temperatures of these water demands were metered and the effluents also measured, it was found possible to draw up a hot water storage scheme coupled with an effluent heat exchanger as a second stage. This showed that a boiler rated at 3,500 lb./hr. of steam could meet the demands and the heat exchanger not only gave a useful fuel saving, but also ensured that if production increased further fuel savings would automatically occur. The scheme is shown in Fig. 1, and the breakdown of costs is as follows:

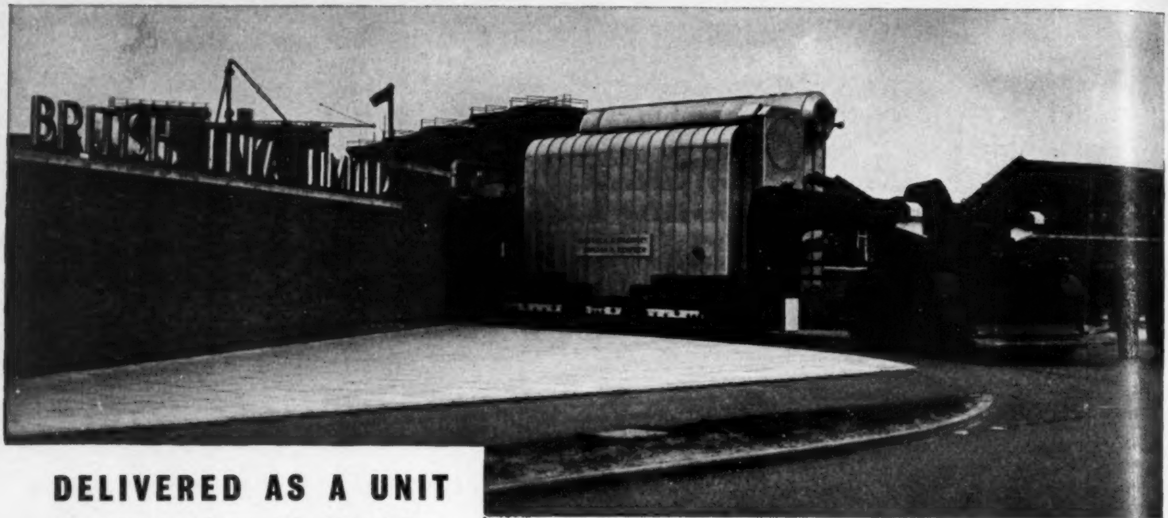
Costs

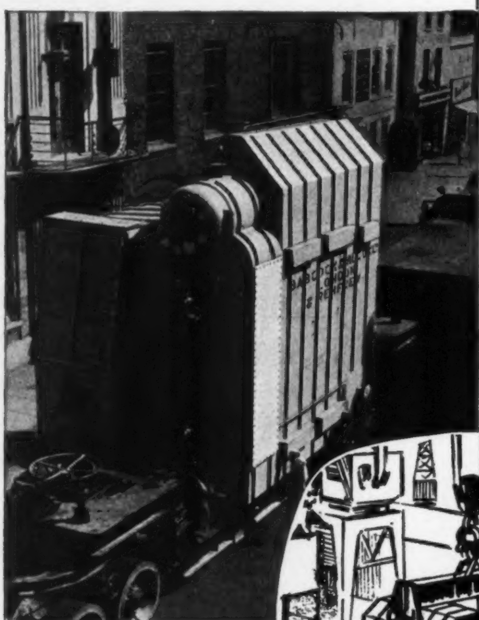
On original assumptions, without storage, capital cost of boiler, etc., £20,000 would be necessary.

With the recommended scheme the capital costs would be as shown in Table 1.

The total capital cost of £13,575 represents a saving of £6,425 compared with the original plans.

On fuel saving alone Stage 2 was not particularly promising, as it would take about five years to pay off. However, if an increase in production capacity were required, this would be a good proposition, since otherwise extra capital would have to be invested





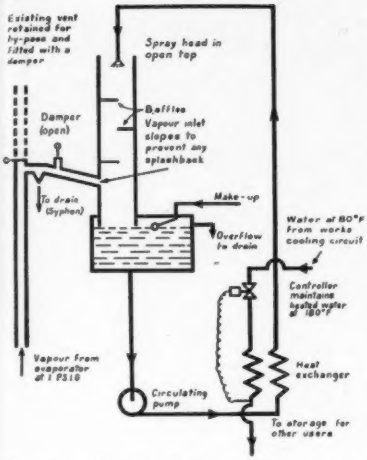


Fig. 2. Method of recovering heat from contaminated vapour

in the boiler and extra fuel required. As an example, increasing boiler size from 3,500 to 4,000 lb./hr., to give some reserve for future production increases, would cost approximately £1,500. The firm could therefore delay this expense, spend less in the event when extra capacity was required and reduce fuel bills by about £250 p.a. when the heat exchanger is eventually installed. Both the effluent pump and heat exchanger were deliberately chosen to be capable of handling 2,000 gal./hr. of effluent, as against the 1,600 gal./hr. calculated sufficient for previous production. The additional water requirements for extra production were, therefore, allowed and it would only be necessary to alter the throttling orifices on cold water and effluent pipes.

Fig. 2 shows a method of recovering heat from contaminated vapour using both a spray condenser and a heat exchanger to obtain clean hot water.

Interchange of information

Very often a chemical company may have a problem which it is unaware exists in other industries, and for which improvements or modifications have already been proved successful. An interesting example of this is a company's process where material is oxidised in batch vessels by suspending it in water and passing air bubbles through the water. The air was introduced by means of a steam jet injector down a central tube to the bottom of the vessel, and the mixture of air and steam ascended through the liquid in the tank. Most of the steam condensed and so kept the contents at boiling point, but some steam was still present in bubbles breaking at the upper surface and there was a considerable vapour loss from the hot liquid. It so happens that the same principle is used in much the same plant in the old type of kier used for bleaching linen. It had already been shown that steam could be admitted by thermostat valve and the process carried out below boiling point with agitation, by occasional use of compressed air or pump circulation. In the linen industry this enabled the open kiers to be enclosed with top plates, resulting in considerable steam savings and increased production.

These ideas were applied to the chemical company mentioned above, using air blown into the vessel by a centrifugal blower. The central pipe could be removed and this enabled a lid to be fitted. The temperature was controlled by thermostat and this resulted in halving the overall steam consumption.

High-temperature fusion

It is sometimes found that chemical works production staff may recognise a problem but are unable to solve it because it is outside their particular field. An advisory organisation such as N.I.F.E.S. may not have worked on this particular process with all its specialised production techniques, but the two parties, by pooling knowledge and experience, may well produce a satisfactory solution.

A good example of this relates to a high-temperature fusion process in which great difficulty was being experienced in obtaining a reasonable life from the externally-fired vessel. Rapid wear and cracking occurred in a few weeks, leading to frequent costly replacements and loss of production. The firm's staff felt that the trouble was due to flame impingement and high combustion chamber temperatures, but detailed tests carried out over a period to measure gas temperatures, vessel skin temperatures and gas flow patterns showed that conditions were no worse than in many other industrial processes where no such difficulties were experienced. It was suggested that the trouble might be caused by the stirrer inside the pot and model investigations confirmed this. The stirrer was leaving a stagnant area over the centre of the pot bottom so that actual local boiling occurred, lifting the fused mass from the metal and allowing it to overheat. As the vapour bubbles collapsed or moved slightly through random effects the overheated metal was suddenly cooled by relatively cool material and the stresses so set up eventually caused cracking. A revised design of stirrer cured the problem; very long vessel lives are now obtained and production has been improved not only by reduced down-time, but also by improved heat transfer from better stirring.

Finally, it is very tempting to utilise all the plant in a department, and batching times and handling problems may be easier as a result. At one firm, however, by using three evaporators instead of four to handle the production load, a 10% reduction in steam cost per ton of product was possible and, by loading dryers to full capacity, one dryer in a battery of six could be shut down and a 5% saving made in steam usage.

Nearly £3 million saved

A saving of nearly £3 million in fuel costs was made by the Central Electricity Generating Board during 1960 due to improved efficiency.

The overall average thermal efficiency of the power stations operated by the Board was 26.71% during the 12 months of 1960, compared with 26.36% for the previous year.

Almost one-third of the 102,891 million units supplied from all stations was provided by the 20 most efficient stations. These stations had an average efficiency of 31.49%.

Analysis and testing of coke

When the revision of B.S. 1016 : 1942 was started, it was decided to formulate the tests carried out on coal and coke in the same terms wherever possible. This object has been achieved in many of the parts already published, but in Part 13 most of the tests described have no counterpart for coal.

The methods for the determination of shatter index and abrasion index have been improved, and the method for the determination of volatile matter now permits the use of electrically-heated furnaces.

Patent report

The Comptroller-General's annual report on the work of the Patent Office in 1960 refers to the continued increase in applications for patents and trade marks, more than half of the complete specifications coming from abroad. Reference is also made to the international activity in industrial property matters, including preliminary consideration, under the auspices of the Council of Europe, of the possibility of a single patent application giving monopoly rights in a number of countries.

Boiling Heat Transfer

By H. K. K. Muthoo,* B.Sc., Ph.D.

Despite its importance, little work has been carried out on boiling heat transfer in order to obtain values for different pressures, superheats, levels of subcooling and convective velocities. In this article a generalised equation for boiling heat transfer is derived; good agreement between the proposed equation and test results was achieved.

THERE exist three types of boiling, namely, nucleate, transition and film boiling. The transition from one type to another is accompanied by marked changes in the hydrodynamic and thermal states of the system. This is characterised by the formation of small vapour bubbles on the heated surface. These bubbles rapidly detach themselves from the surface and grow as they rise through a thin superheated layer close to the heated surface. The growth of the bubbles and their escape velocity produce large heat transfer rates by creating turbulence within the fluid; this is normally associated with boiling heat transfer.

It is the purpose of this paper to consider the derivation of the correlating equations of boiling heat transfer based upon the mechanism of boiling close to the heated surface.

Earlier investigations

To understand the mechanism of nucleate boiling a distinction must be made between what happens whilst a vapour bubble adheres to the heating surface and how this bubble grows after breaking from that surface.[3] These two phases differ from each other by both the differences in temperature as well as by the manner of hydrodynamic motion. The mechanism of bubble formation and its break-off from the surface, as understood, is shown in Fig. 1.

Chang[2] was the first to introduce hydrodynamics to relate the thickness of the wave-layer for thermal diffusion with the depth of the fluid through which the bubbles move. He originated the differential equation for the temperature distribution across the wave-layer:

$$\frac{\partial\theta}{\partial t} = \alpha\frac{\partial^2\theta}{\partial y^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

where

$\alpha =$ the thermal diffusivity of the fluid

$= k_a/\rho_a C_{pa}$

k_a, ρ_a and C_{pa} denoting the thermal conductivity, density and specific heat at the mean temperature of the wave-layer

and $\theta =$ the temperature difference between any point in the wave-layer and the upper surface of the boundary film.

Using the proper boundary conditions (Fig. 2), the solution is:

$$\theta = \theta_{ac}\left\{1 - erf\left[\frac{y}{2\sqrt{(\alpha t)}}\right]\right\} \quad \text{(2)}$$

where $\theta = T_s - T$

and $\theta_{ac} = T_s - T_a$

The time required to obtain a given temperature at a distance from the upper surface of the boundary film is proportional to the square of the distance y. At $y = 2a$, $\theta = 0$, then

$$erf\left[\frac{y}{2\sqrt{(\alpha t)}}\right] = 1 \quad \ldots\ldots\ldots \text{(3)}$$

Chang also observed that the minimum wavelength of oscillation exists at a time of peak flux when the bubbles start leaving the liquid-vapour interface as fast as they are released from the points of nucleation. One difficulty is to determine the magnitude of the minimum wavelength.

Zuber[4, 10] followed a similar line of investigation to analyse the stability criteria in the transition zone of boiling heat transfer (Fig. 3). Although the peak flux distribution with respect to pressure was comparable with that obtained by Addoms,[1] the minimum flux corresponding to point D of Fig. 3 fell short of the values reported by McAdams.[7]

Jens and Lottes[5, 6] have managed to obtain empirical correlation between mass flow, temperature drop and heat fluxes. They summarised experiments on surface boiling of water flowing upwards in vertical electrically-heated tubes of stainless steel and nickel. The data was correlated by the dimensional equation:

$$\Delta T_{sat} = T_w - T_{sat} = \frac{1.9(q/A)^{\frac{1}{4}}}{e^{P/900}} \quad ..\text{(4)}$$

where P is the absolute pressure in p.s.i.

The peak flux was correlated by the dimensional equation:

$$\frac{(q/A)_b}{10^6} = a_3\left(\frac{G}{10^6}\right)^m (T_{sat} - T)^{0.22} \quad ..\text{(5)}$$

As pressure increased from 1,000 to 2,000 p.s.i. abs. the average value of a_3 decreased from 0.76 to 0.51 and m increased linearly from 0.27 to 0.50.

With all this information we still do not know, from the practical point of view, the effect of two-phase,

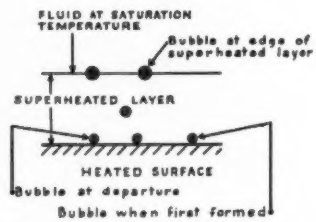


Fig. 1. Simplified model of boiling heat transfer

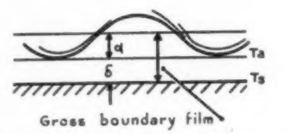


Fig. 2. Boundary layer close to heated surface

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two-component flow on the temperature drop. None of the investigators has given any explanation as to how and when the liquid superheat jumps from a low to a high value, for the same amount of heat flow, in the region denoted by CD (Fig. 3).

Mechanism of nucleate boiling

The general mechanism of boiling in the nucleate zone is, according to Chang, Zuber[4] and many others, that the vapour nuclei grow into bubbles and leave the metal surface (Fig. 1). Their motion through the superheated fluid initiates oscillation at the liquid-vapour interface. The velocity with which the bubble approaches the interface is a measure of heat transferred from the wall to the saturated liquid. Chang observed that the wavelength of these oscillations will change from a maximum at the beginning of nucleate boiling to a maximum at the end of the nucleate zone, and once again increases to a maximum at the end of the transition zone. The wavelengths increase from a minimum to a maximum. Under what particular conditions the transition zone is transversed is not yet well defined.

Milne-Thompson[8] and Lamb[9] refer to experiments in which water is retained by atmospheric pressure in an inverted tumbler whose mouth is closed by gauze of sufficiently fine meshes. The mesh size should not exceed $\lambda/2$ where λ, the wavelength, is given by:

$$\lambda = 2\pi\left[\frac{\sigma}{g(\rho_L - \rho_v)}\right]^{\frac{1}{2}} \quad \ldots\ldots\ldots(6)$$

According to Milne-Thompson, if the equations of pressure distribution in a system consisting of two fluids of different densities are re-examined a distinct possibility occurs that the depths of both fluids may not be infinity compared with the wavelength of oscillation of the interface.

Assuming that both the depths are equal and less than $\lambda/2\pi$, and following the argument presented by Zuber regarding the transfer of energy, the following expression is arrived at:

$$\frac{Q/A\lambda}{h_{fg}\rho_v} = \frac{\lambda}{24}\left[\frac{2\pi g_o\sigma}{\lambda}\,\frac{(\rho_L + \rho_V)\,R}{\rho_L\,\rho_v}\right]^{\frac{1}{2}} \quad (7)$$

The value of R can be based on the experimental work reported.[7] From equation (3) and the above assumption the minimum wavelength will be:

$$\lambda_{min} = B_1(\alpha L^2/\sigma g_o)\,(\rho_L + \rho_v) \quad \ldots(8)$$

Maximum heat flux

Equation (7) represents the velocity of the bubble that acts as a carrier of heat across the interface. At the maximum heat flux the velocity of the water vapour bubble is in the region of 5 ft./sec., at atmospheric pressure.

In the author's opinion the contribution of heat by this mechanism is due to more than the pure convective mechanism where the bulk of the liquid plays a significant part in the mode of heat transmission, when ripples in the boundary layer are absent. When boiling inside a tube is considered, at extremely low heat flux (below that required for the initiation of nucleate boiling), a temperature gradient will exist due to normal convective conductance. The liquid in contact with the wall will be vaporised inside the boundary layer, since the temperature of the liquid core in the tube is at the saturation point. The vapour film will be compressed due to the velocity gradient in the sublayer, thereby causing higher temperature gradient than if the liquid were at a temperature below that of saturation. The conductivity of the vapour film will again affect the temperature drop. The temperature drop and heat input will be as shown in Fig. 4 if there is some subcooling. This non-uniform distribution of heat flux at the inner surface may be attributed to the flow inside the metal itself.

As the heat flux is increased, the temperature drop will also increase, but the radial pressure distribution due to flow will constantly compress the superheated vapour film until the layer is so small in thickness that nucleation begins. Once this phenomena starts, the temperature drop will gradually diminish, since the nucleus of the bubbles detaches itself from the surface under the hydrodynamic forces. This point marks the beginning of the nucleate zone. The maximum wavelength at which the interface oscillates is given by the equation (6). Modifying equation (6) to take into account the gravitational forces gives

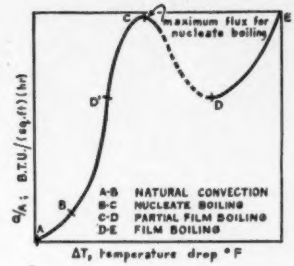

Fig. 3. Different régimes of boiling heat transfer

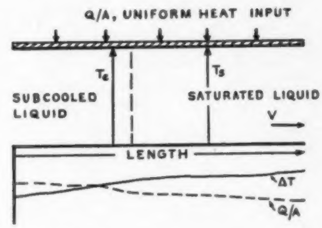

Fig. 4. Effects of subcooling on temperature drop

$$\lambda_{max} = 2\pi\left[\frac{g_o\sigma}{g(\rho_L - \rho_v)}\right]^{\frac{1}{2}} \quad \ldots\ldots(9)$$

An assumption can be made to the effect that the depth of phases is constant throughout the nucleate zone and is of magnitude $R(\pi_{min}/2\pi)$. The heat flux at the beginning of the nucleate zone can be evaluated as the wavelength is maximum at that point. Hence, at point B (Fig. 3)

$$\frac{(Q/A)_B}{h_{fg}\rho_v} = \frac{\lambda}{24}\left[\frac{2\pi g_o\sigma}{\lambda^2_{max}}\,\frac{(\rho_L + \rho_v)}{\rho_L\,\rho_v}\,R\lambda_{min}\right]^{\frac{1}{2}} \quad (10)$$

There are three zones of boiling for a given heat flux beyond point D' (Fig. 3), and consequently there are three different temperature drops. Data are not yet available concerning the process by which we can traverse from

NOMENCLATURE

- A = Heating surface area, sq.ft.
- B_2 = Constant of proportionality, 0.0151
- B_3 = Constant of proportionality, 0.0178
- C_p = Specific heat at constant pressure, B.T.U./lb. °F.
- h_{fg} = Enthalpy of evaporation, B.T.U./lb.
- g_o = Constant for conversion to mass units, 32.2 ft./sec.^{2}
- g = Acceleration due to gravity, ft./sec.^{2}
- k = Thermal conductivity, B.T.U./sq.ft.hr. °F./ft.
- Pr = Prandtl number
- Q = Heat transfer rate from heating surface, B.T.U./hr.
- R = Proportionality constant, 0.1775
- Ts = Saturation temperature, °F.
- v = Velocity, ft./sec.
- V = Specific volume, cu.ft./lb.
- α = Thermal diffusivity, sq.ft./hr.
- μ = Viscosity, lb./hr.ft.
- λ = Wavelength, ft.
- σ = Surface tension, lb./ft.
- ρ = Density, lb./cu.ft.

Subscripts:

- L = liquid
- v = vapour

Table I

Pressure p.s.i. absolute	x	$(Q/A)_D'$	$\Delta T_D'$	$(Q/A)_B$	ΔT_B
1,000	0.00	3.90×10^5	16.00	1.15×10^5	10.75
	0.10	2.70×10^5	13.20	3.56×10^4	7.25
	0.50	1.10×10^5	10.30	5.40×10^3	3.85
2,700	0.00	2.73×10^5	3.32	8.75×10^4	2.28
	0.10	2.40×10^5	3.20	6.00×10^4	2.19
	0.50	1.06×10^5	2.43	1.58×10^4	1.50

point D′ to D through C and retrace the path. Since D′ and D (Fig. 3) are on the same level of heat flux in the nucleate and film boiling zones respectively, it should be possible to keep the metal temperature at a minimum level if the régime of boiling between B and D is restricted. Hence at D the following will occur:

$$\frac{(Q/A)_D}{h_{fg}\rho_v} = \frac{\lambda}{24}\left[\frac{2\pi g_o\sigma}{\lambda_{max}}\,\frac{(\rho_L+\rho_V)}{\rho_L\,\rho_v}\,R\right]^{\frac{1}{2}} \quad \ldots.(11)$$

Equations (6) to (11) are applicable only at saturation temperature.

If a mixture of liquid and vapour is present, the radial pressure distribution will depend on the local density of the liquid-vapour mixture. When two-phase flow occurs, there may be slip flow at or near the boundary film, and even in the main core of the fluid, or the flow may be simple homogeneous flow and then the density of the mixture can be shown by the following equation:

$$\rho' = \frac{1}{[V_L(1-x)+V_vX]} \quad \ldots\ldots(12)$$

Since the mass balance has to be maintained during the exchange of energy, via the mass migration of bubbles, the enthalpy of vaporisation will be $(1-x)h_{fg}$. Hence at a given dryness ratio the heat inputs and wavelengths could be obtained by substituting $(1-x)h_{fg}$ for h_{fg} and ρ for ρ_L in equations (6) to (11).

On the basis of a bubble Reynolds Number[10] empirical correlation between temperature drop and heat flow has been proposed; but the correlation suffers from a great setback of determining the pressure gradient across the superheated film, and hence it becomes somewhat difficult to use.

As the bubble travels through a liquid of varying temperature, the rate of growth of the bubble changes with the temperature of the surrounding liquid. The transfer mechanism can be supposed to consist of three successive stages, namely, from the wall to the vapour film (a very thin layer), from the vapour film to the bubble, and finally from the bubble to the bulk of the fluid. Based on the energy balance and the experimental values reported,[7] the following two empirical expressions for the temperature drop and heat flow can be developed.

In the nucleate zone:

$$\frac{\Delta(T)C_{p,v}}{h_{fg}} = B_2\left[\frac{(Q/A)}{\mu_v h_{fg}}\sqrt{\frac{g_o\sigma}{g(\rho_L-\rho_V)}}\right]^{\frac{1}{3}} \times \left(\frac{\lambda_{min}}{\lambda_{max}}\right)^{\frac{1}{3}}(Pr)_v^{\frac{1}{3}} \quad \ldots\ldots\ldots\ldots(13)$$

and in the film zone:

$$\frac{\Delta(T)C_{p,v}}{h_{fg}} = B_3\left[\frac{(Q/A)}{\mu_v h_{fg}}\sqrt{\frac{g_o\sigma}{g(\rho_L-\rho_v)}}\right]^{\frac{1}{3}}(Pr)_v^{\frac{1}{3}} \quad \ldots\ldots\ldots\ldots(14)$$

where B_2 and B_3 are equal to 0.0151 and 0.0178 respectively, based on the figure 14.1.[7]

In order to take into account the effect of dryness ratio, ρ_L and h_{fg} will be replaced by ρ and $(1-x)h_{fg}$, for reasons mentioned above. Although no experimental evidence is available to demonstrate the effect of dryness ratios on temperature drops and heat inputs, an attempt has been made to show the same (see Table 1). The heat transfer coefficients obtained using equations (6) and (13) are in good agreement with those obtained by Addoms[1] (Fig. 5) for peak heat flux in boiling water.

Equation (13) could be rewritten in a more convenient form as:

$$Q/A = \frac{\Delta T^3}{M_4} \quad \ldots\ldots\ldots\ldots\ldots\ldots(15)$$

where

$$M_4 = \left(\frac{1}{B_2}\right)^3\left(\frac{C^2_{p,v}K_v}{h^2_{fg}}\right)\left(\frac{\rho_L-\rho_v}{\sigma}\right) \quad \ldots\ldots\ldots\ldots(16)$$

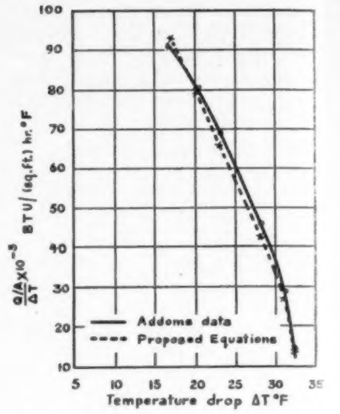

Fig. 5. Correlation of proposed equation with Addoms' data

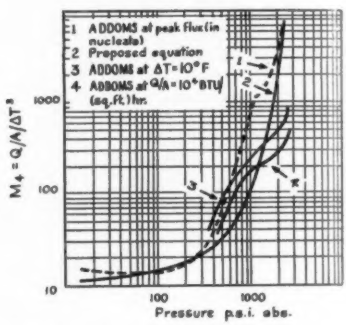

Fig. 6. Empirical determination of coefficient M_4

Although the value of ΔT depends on the dryness ratio, the fact that in the nucleate zone the temperature drop decreases very rapidly with dryness ratio makes it possible to use the value of M_4 determined at zero dryness. This would normally give a safe margin on metal temperatures. Fig. 6 shows that by comparing equation (16) with the values obtained from Addoms[1] a good correlation was attained.

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Design of Modern Water-tube Boilers

By A. K. Gemmell, A.M.I.Mech.E., A.M.Inst.F.

Since the end of the war design of steam-raising plant has changed considerably. Many more boilers are now burning fuel oil, hence more attention is paid to impurities in the oil that may cause corrosion. Apart from an increase in evaporative capacity, the pressure and temperature of boilers have also increased considerably. These new trends are discussed in this article and some typical examples of modern boiler installations are given.

THERE are a number of factors affecting the design of modern boilers, particularly with regard to large water-tube boilers.

The trend to increase the size of generating units in recent years has led to an increase from 30 to 500 MW. Apart from the increase in evaporation of the boiler units, the pressure and temperature have also appreciably increased. This has affected boiler design considerably, so that the boiler now consists of a large radiant furnace, the remainder of the heating surface consisting of a superheater and a reheater. In these large boilers there is very little convection surface. Although industrial boilers have not greatly increased in evaporation rates, there has been a trend towards higher pressures and temperatures resulting in a redistribution of heating surfaces.

The experience gained due to research carried out on fuels and the effects of sulphur, chlorine and vanadium has resulted in an increase in the pitch of superheater tubes and a reduction in the gas temperature leaving the combustion chamber.

Increased steam temperatures and pressures are due to improvement in the steels available. The accepted temperature range for the superheated steam is between 1,060° and 1,100°F. The higher pressures and temperatures obtainable have materially increased the overall thermal efficiency cycle. There are now single and double reheat cycles. These points also influence the design of the boiler units.

Coal

With increasing price of coal the cost of steam is significantly increased. Again with cheaper-quality coals containing high moisture and ash, the cost is increased due to extra handling of the coal and ash and by the cost of installing dust extraction plant. In addition there is also the cost of disposing of the dust from pulverised fuel boilers; this is discussed later.

The design of the boiler must allow for wide variations in the quality of coal. Two of the most troublesome chemicals found in coal are chlorine and sulphur. Both chlorine and sulphur are responsible for deposits on the heat-transfer surfaces. The sulphur may form SO_2, SO_3 and H_2SO_4 with the oxygen and moisture, the acid so formed leading to corrosion of the economiser and/or air heater when the metal temperature is below the dewpoint of the gases. This might mean running with a high chimney temperature and a reduction in efficiency to avoid acidic deposits and corrosion of heating surfaces. If deposits of ash form on the tubes, the heat transfer from gas to water is lowered, the duty of the induced-draught fan is increased and the control of the fuel/air ratio becomes more difficult, all this leading to high back-end temperatures and lower boiler efficiency.

Where deposits are formed, the removal of these deposits either by steam or air blowers or water washing requires careful consideration.

To decrease the high exit temperature, the elements of the air inlet portion of a rotary regenerating air heater can be made from Corten steel which has a greater resistance to corrosion. When a tubular air heater is installed, it can be made in two sections, a small air inlet section which can be easily retubed, and a larger section which is thus protected from corrosion. Cast iron, which is more resistant to corrosion than mild steel, may be used for air heaters. For the larger boilers, the dimensions of the recuperative air heater are much greater than for the regenerative air heater.

With lower-quality fuels, lower ash fusion temperatures, increase in ash content and higher heat liberation, there is a more rapid accumulation of slag on the furnace walls. Also, with close pitching of the tubes in the convection zone, the velocity of the gas will be high and will accelerate the build-up on the tubes in this zone. The furnace outlet temperature is thus increased by the deposits on the furnace walls. To overcome these difficulties the design must allow for a combination of furnace volume and water cooling so that the heat absorbed by the furnace walls will assure that the furnace outlet temperature is below the ash fusion temperature of the lowest quality fuel. The outlet temperature must also be sufficiently high to give the required steam temperature. The spacing of the tubes in the convection zone is increased to reduce the entering gas velocity and slag formation.

The larger the boiler, then the greater is the need for dust extraction plant, which may be either mechanical, electric or a combination of both.

Oil

There has been a considerable increase over the last decade in the number of oil-fired boilers. The calorific value of each grade of oil is more constant than that of coal and less ancillary equipment is required. Oil is much more easily handled, as it can be pumped from road and rail tankers or from water-borne tankers and barges to the storage tanks and from the latter to the daily service tanks. Less tube surface cleaning than for coal-fired boilers is necessary and no ash handling equipment whatever is required. The sulphur and vanadium content of oil fuels, however, can cause corrosion and deposits on heating surfaces. The sulphur and hydro-

gen content of oil increase the risk of producing greater quantities of sulphuric acid, which means that the back-end temperature must be above the dewpoint of the acid. Experiments are being carried out introducing additives to the oil in order to reduce sulphuric acid formation.

The main essential to obtain efficient combustion is contact of the air with fuel in the correct quantities, the necessary time for the chemical reactions between the fuel and the air, the correct temperature to initiate and maintain combustion, turbulence to give intimate mixing of the fuel and gaseous products with the air.

Increasing boiler capacity

The trend in modern power stations is to increase the size of the unit. The cost per kW installed of one 500-MW boiler and associated turbo-alternator is much cheaper than installing 30-MW sets, and the building volume is greatly reduced.

The boiler must be designed to burn the basic fuel and also allow for wide variations in the analysis of the coal. Once the steam conditions are known, the quantity of fuel, the size of the combustion chamber and the position of the superheater, reheater, economiser and air heater are then considered. The circulation system may be of the natural, assisted or forced type. Some manufacturers have natural circulating boilers operating up to 2,750 p.s.i.g. Others may adopt the controlled-circulation type for pressures above 2,000 p.s.i.g., to assure adequate circulation under all conditions. The controlled-circulation type assures greater freedom for tube arrangements and permits the use of smaller tubes. The circulation is controlled by orifices at the tube entry; should a furnace tube burst the leakage is limited due to the restricted water flow in each tube and the boiler can be kept in operation until it is convenient to repair the burst tube at a later stage.

Modern boilers

The chief aim in modern boilers is to obtain high availability, high efficiency and ability to burn a wide range of coals on stoker and pulverised fuel-fired boilers.

The steam conditions for normal water-tube industrial boilers may vary between 150 and 800 p.s.i.g. and temperature between saturation and 850°F. The load may vary between 20,000 and 200,000 lb./hr. The boilers can be stoker-fired, oil-fired, gas-fired or fired by coal-tar fuel.

The size of stoker required to burn the coal for the stated conditions governs the size of the combustion chamber.

Chain-grate stoker

This stoker should be able to operate over a wide range of loads. The loss due to carbon in the ash, and the dry flue gas loss due to excess air, should be a minimum. It should be possible to control the air over the length of the stoker by dampers fitted under the top portion of the grate. The burning rate of the coal should be such that an excessive amount of grits are not carried over into the gas passes. The temperature of the primary and secondary air to the stoker should be as high as possible up to a maximum of 300°F. If air temperature is too high then grate links may be damaged by burning.

Pulverised fuel boilers

In large, modern power stations the boiler is suspended from the building roof steelwork and is free to expand downwards. Provision is made between the boiler furnace outlet and the ash hoppers to allow for expansion and a seal provided between the boiler and the hoppers. Baffles are reduced to a minimum in order to reduce resistance to flow of the gases.

The height and volume of the furnaces have greatly increased and the use of platen-type superheaters in the upper portion of the furnace reduces the gas-leaving temperature to below the ash fusion point.

The boilers may be skin cased, *i.e.* a steel casing is placed firmly against the outer surface of the wall tubes and welded to the support channels which surround the furnace at different levels. Insulation is then firmly fitted between this inner casing and an outer steel casing.

Superheat control can be by by-pass dampers, water-spray-type desuperheaters, gas recirculation or by tilting of the fuel burners.

The majority of large boilers have dry bottom furnaces which give good service and availability. The main problem with pulverised-fuel-fired boilers with dry bottoms is the disposal of dust, which may be carried out by filling disused sand pits or, if near the coast, by dumping at sea. A slag tap boiler will reduce the handling of the ash and dust. Continuous slagging furnace boilers are now available where there is a constant discharge of liquefied ash from the bottom of the furnace into a water trough; the ash is disintegrated into a hard, clean, pellet-like slag, which is easy to handle and has an industrial value.

Water treatment

In the past it was considered adequate to supply water free from hardness. In modern boilers, however, with the ever-increasing pressure and heat rating, this alone has not been found adequate and great attention is now paid to the silica content, the total dissolved solids and oxygen. The first two play a vital part in steam purity and their control is necessary to ensure freedom from internal superheater deposits and turbine blade fouling. The total dissolved solids and silica are most effectively removed by ion-exchange processes and these are tending to replace evaporators.

The oxygen content must be kept low to minimise corrosion, and scavengers such as hydrazine may be used for this purpose.

Modern boiler installations

A few examples of modern boiler installations are given below.

Three industrial boilers each rated at 50,000 lb./hr. at 425 p.s.i.g. and 810°F. are of the natural twin-circulation type. The superheater is of the pendant type arranged in two stages, with the desuperheater comprising coils submerged in the steam drum, interposed between the two stages. Each boiler is designed for sandwich firing of coal and coke and for burning of coke-oven gas. Each boiler is provided with an economiser and mechanical dust collector.

In a modern power station the boilers are each rated at 3,450,000 lb./hr., at 2,400 p.s.i.g. and temperature 1,055°F. The reheater, arranged in two stages, reheats 2,740,000 lb./hr. at 592 p.s.i.g. from 688° to 1,055°F. The boilers are of the controlled-circulation type, each having four boiler circulating water pumps. Any two of these pumps is suitable for the C.M.R. of the boiler. There are two combustion chambers divided by a water-cooled wall. The superheater and reheater are evenly distributed over the width of the boiler. The reheater temperature is controlled by tilting the pulverised-fuel burners and the superheater temperature by spray-type desuperheaters interposed between the third and fourth stages. The boiler is provided with six pulverised-fuel mills, any five of which will carry the C.M.R. of the boiler. Three rotary regenerative air heaters are also provided for each boiler.

CRYSTALLISATION

By A. W. Bamforth*

This annual unit operations review surveys new developments in crystallisation since the last published review in February 1960. A considerable number of new publications on this subject have appeared during the past year. Fundamental investigations into crystal structure have continued and many interesting processes in the heavy inorganic and petrochemical industries have been devised which incorporate crystallisation at one stage. There are 86 references altogether.

ONE of the most important contributions to the literature, Mullin's 'Crystallisation' was published earlier this year. In a clear and concise manner, Mullin[1] has considered all aspects of this important process from the fundamental theories concerning crystal structure and growth to the various types of individual equipment at present used.

Other compilations on selected aspects of the study of crystallisation have appeared. Chalmers[2] reviews the growth of pure materials, and Carbrera[3] has summarised existing knowledge of crystal surfaces, including the classification of interfaces, defects and energy exchange between absorbed atoms and the crystal surfaces. Langer[4] has reviewed the available literature on the subject of crystal structure, giving 54 references.

A review giving 223 references on the present-day concepts of the strength of crystalline substances has been presented by Garber and Gindin.[5] Honigmann[6] has prepared a well-illustrated monograph on the subjects of supersaturation, crystal growth from solution, melt or vapour phase. The growth of metal oxides during calcination has been reviewed by Norton.[7]

The present state of research on crystallisation embodying discussions on both conventional theories and newly adopted views on crystallisation, grain growth and recrystallisation is surveyed by Borchers *et al.*[8]

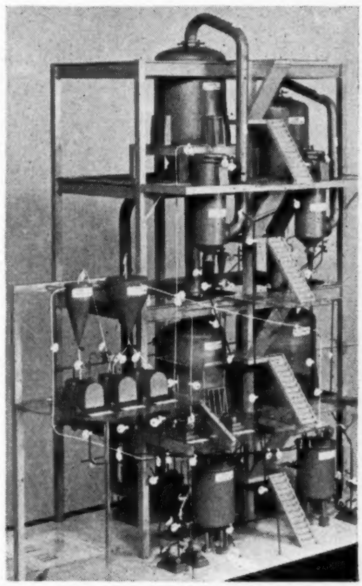
Crystal structure and growth

Investigations into the crystallographic structure and growth of various substances has continued. Studies on crystal structure include that of calcium cyanide,[9] copper fluoride dihydrate,[10] barium, strontium and lead selenates[11] anhydrous sodium sulphite,[12] thiourea,[13] gypsum[14] and ammonium monohydrate.[15] The crystal structure of 4.4 - dibromoazoxybenzene,[16] 3.3 - dibromobenzophenone,[17] diformylhydrazine[18] and quinhydrone[19] have also been investigated.

The growth rate of calcium sulphate dihydrate, and the effects of initial supersaturation, crystal surface area, *p*H, and the addition of surface-active agents upon the growth rate has been determined by Schierholtz.[20] Packter[21] has considered the growth rate of soluble metal salts, and the factors which determine the size of the crystals when grown by cooling hot saturated solutions.

Discussion on the growth and solution of crystals from both pure and impure solutions has been made.[22] The effect of the absorption of sodium sulphate upon the growth rate of sodium chlorate crystals, and of borax upon the growth rate of magnesium sulphate septahydrate has been studied by Bliznakov.[23] Yuan-Lung Chang[24] has studied the growth of sodium chloride crystals from sublimed vapour. Kleber *et al.*[25] have reported experimental results on their investigations into the effect of admixtures on the growth of calcium chloride from aqueous solutions.

The effect of stirring upon the rate of crystallisation of glucose has been reported by Sadovyi and Chubik.[26] Van Hook *et al.*[27] have confirmed the



Model of a Krystal plant designed by the Power-Gas Corp. Ltd. for production of benzoic acid crystals, part of the Snia Viscosa caprolactam process

Kucharenko tables dealing with the rate of growth of sucrose crystals. The rate at which sugar is deposited on established crystals in various molasses has been reported.[28] Using a refractive method, Gudz[29] has studied the crystallisation of sucrose from water over the temperature range 30° to 80°C. at various degrees of supersaturation and various stirring rates.

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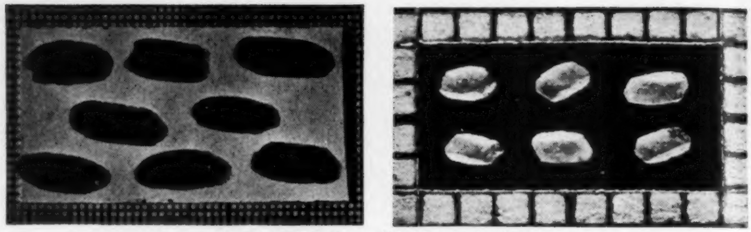
Experiments by Miyoshi, Ogami and Saeki[30] show that by the addition of a small amount of m-phenol-sulphonic acid, its salt or its solution, formaldehyde polymer, during the crystallisation of NH_4Cl from solution, non-caking crystals with a uniform large grain size are obtained. The rates of crystal formation and growth during mass crystallisation in a stirred solution has been studied by Matusevich.[31] The same author has found that the purity of crystals of potassium nitrate and potassium ferrocyanide, crystallised from solution containing potassium chloride, improves with the intensity of stirring.[32]

Investigating the crystallisation characteristics of aqueous KBr and NaCl solutions, Gyulai[33] has shown that these solutions may supercool approximately 20°C. During slow cooling a small number of crystal nuclei are formed on which some salt crystallises. The vigorous agitation of the supersaturated solution produces intensive nucleation which becomes very rapid after a sluggish beginning and terminates gradually. The effect of surface-active agents on crystal growth and habit with reference to adipic acid crystallised from water has been investigated by Michaels and Colville,[34] who report that the growth rate of the individual faces of the adipic acid crystals can be correlated with saturation level in terms of nuclear theory. Satarovkin and Kulikov[35] have carried out experiments to show the influence of an electric field on the crystallisation of ammonium chloride.

Modifications to the crystal habit of diammonium phosphate due to the presence of nitrate, sulphate and ferrocyanide ions are discussed by Smith, Lehr and Brown.[36] A change in habit from a cube to an octahedron of potassium bromide when in the presence of phenol has been found by Bliznakov *et al.*[37] The effect of the absorption of impurities on the equilibrium and growth forms of crystals is generally discussed by Lacmann and Stranski.[38] Electron microscopy was used by Takiyama[39] to study the change of crystal shape of freshly prepared and aged barium sulphate. The crystallisation of deformation twinning is formulated on a new mathematical basis by Jawson and Dove.[40]

Single crystals of the heptahydrates of magnesium, nickel and zinc sulphate, and of the double magnesium/nickel, magnesium/zinc sulphates[41] and of potassium chloride, bromide and iodide[42] have been prepared and studied. A method of growing mono-crystals of inorganic salts in sealed



Crystals of copper sulphate pentahydrate

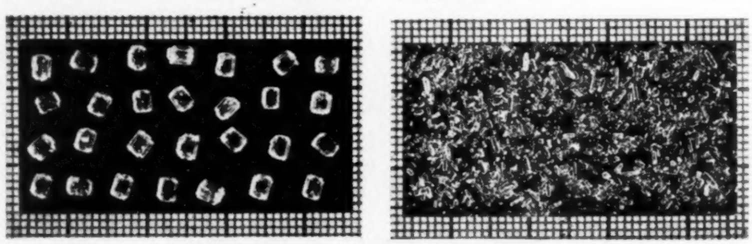
ampoules has been patented.[43] The synthesis of mono-crystals of guanidine aluminium sulphate was investigated by Chapelle and Chollot.[44] Tanaka and Waku[45] have investigated the growth of single crystals of triglycine sulphate and have determined the solubility, metastable region of supersaturation and the density of this salt.

Fertilisers

As a result of the large number of nylon-6 plants now being projected,[46, 47] more caprolactam will be required, and up to 1,000,000 tonnes of by-product ammonium sulphate can be expected from this source during 1961. Inevitably this increase in supply must reflect upon the economics of ammonium sulphate from other sources. Interest in ways and means of improving the growth and free-flowing characteristics of ammonium sulphate and to prevent caking during storage continues. The addition of non-ionic surface-active agents, polyglycols and cationic surface-active agents to crystallising ammonium sulphate solutions has been patented[48] and the effect of small amounts of Fe, Cu and boric ions on the crystallisation of ammonium sulphate has been reported.[49] The addition of chromic formate, acetate or oxalate is claimed to prevent caking of ammonium sulphate in storage.[50]

A process to treat waste liquor containing iron in solution to produce ammonium sulphate essentially iron-free and a by-product iron carbonate has been patented.[51] The liquor after treatment with a mixture of NH_3 and CO_2 is sprayed into a reaction vessel, where in the lower part the gases react with the liquor and go into solution as ammonium carbonate and/or bicarbonate which further react with the soluble iron to form a precipitate of iron carbonate. The gas stream passes on into the upper part of the vessel, where the NH_3 in the gas is scrubbed out with acidic liquors to form a solution of ammonium sulphate. The iron carbonate is removed by filtration and the last traces of iron removed by treatment with H_2S. The solution separated from the precipitated iron sulphide is evaporated and crystals of ammonium sulphate obtained.

A patent from OSAG[52] refers to the production of ' rice grain ' sulphate by saturating an aqueous solution of ammonium sulphate with CO_2 and NH_3 in the stoichiometric proportions required to produce ammonium carbonate and then treating the solution with gypsum or anhydrite to produce ammonium sulphate by double decomposition.



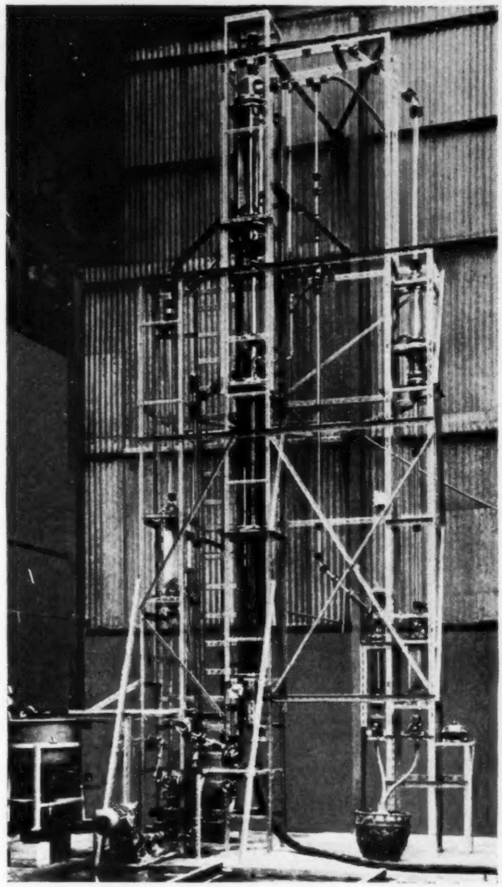
Crystals of ammonium sulphate (gas/acid process)

The investigations into the growth rate of by-product gypsum from phosphoric acid process by Yamada *et al.* have been continued[53] and Zolotov[54] has studied the effects of partially dehydrating gypsum and the crystallisation of the hemi-hydrate. The process of growth of precipitated calcium carbonate and the conditions relating to the formation of calcium carbonate crystals has been investigated by Sakaguchi[55] and Jono *et al.*[56] respectively.

Lee[57] has patented what is claimed to be an improvement in the method of production of phosphoric acid for fertiliser use from phosphate rock and sulphuric acid. In connection with the production of diammonium phosphate

from ammoniacal liquor and phosphoric acid, Woodall-Duckham Construction Co.[58] have patented an apparatus whereby ammonia is distilled from the liquor into a preheated phosphoric acid bath; reaction gases are withdrawn, cooled to condense water vapour, reheated and recycled through the bath to evaporate excess water therefrom. The recovery of ammonia from coke-oven gas in a phosphoric acid solution and the production of diammonium phosphate by evaporation and subsequent drying and granulating have been patented by Helm and Schulte.[59] It is claimed that the process can be applied by existing absorbers in plants designed to manufacture ammonium sulphate and therefore the additional capital investment is low.

The production of tri-sodium phosphate and alumina from aluminium, iron and phosphate ores was studied and reported upon by de Wet and Schulz.[60] The crystallisation of sodium aluminate from aluminate solutions was carried out by Ponomarev and Sazhin.[61]



A Krystal pilot plant installed by the Power-Gas Corp. Ltd. All vessels and pipework are in glass

Sea-water

A new process for producing drinking water from sea-water, based on the controlled crystallisation of sea-water to produce ice crystals, has been successfully tested.[62] Previously, owing to the difficulty of separating salt absorbed at the surfaces of the very small ice crystals formed, freezing was not an economical process. The new technique makes it possible to increase the size of the ice crystals and thereby to carry out effective separation and washing of the ice.

Pilot-plant trials with sea bitterns reported by Bhavnagary and Gadre[63] indicated that potassium sulphate can be obtained at 98% purity. Sea bittern is solar evaporated to obtain schoenite, a double salt of magnesium and potassium sulphate which is subsequently decomposed by treatment with potassium chloride and lime. The production of potassium sulphate from kainite, the double salt of magnesium sulphate and potassium chloride, has also been reported.[64] The process is based upon the relatively high solubility of magnesium salts as compared with potassium salts.

Perlmutter[65] has patented a process for recovering potassium chloride from brines saturated with magnesium chloride and containing K, Na and Ca chlorides. The growth of potassium chloride crystals from aqueous solutions was investigated by Sears.[66] Behrens and Ebner[67] have taken out a patent claiming to improve the crystallisation of potassium salts by stepwise cooling and improved heat exchange.

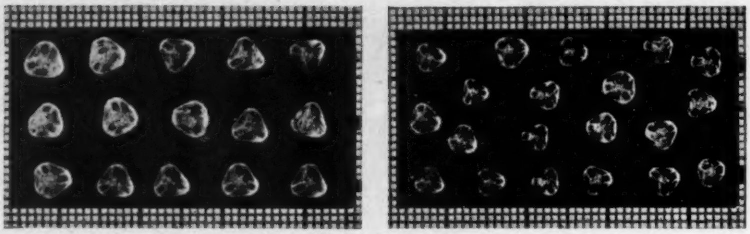
Schmidthals[68] has patented a process for preparing potassium nitrate from potassium chloride and sodium nitrate using sea-water as the solvent. Mixed solutions are concentrated by evaporation to crystallise out the sodium chloride. The mother liquor is then cooled to crystallise potassium nitrate.

A process patented by Jannuzzi[69] covers a series of double decomposition reactions wherein the magnesium in sea-water is precipitated as magnesia by the addition of lime, is then converted by sulphuric acid and crystallised as magnesium sulphate. The by-product calcium sulphate is then converted into ammonium sulphate by the addition of ammonium carbonate. The chalk resulting from this reaction is treated with nitric acid and crystals of calcium nitrate obtained. By reacting CO_2 with a suspension of magnesia and gypsum in water recovered from sea-water, bitterns conversions up to 90% magnesium sulphate have been obtained.[70] Moriyama *et al.*[71] have determined that the rate of growth of calcium sulphate dihydrate and gypsum in sea-water is proportionate to the temperature and independent of the original concentration.

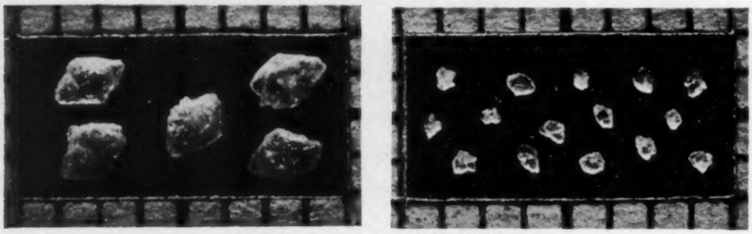
Methods of improving the size and shape of sodium chloride crystals have been patented, including the addition of nitriloacetate[72] and a synthetic polyelectrolyte.[73] The latter is claimed to produce a crystal of low bulk density, 0.75 g./c.c. A plant for producing 50,000 tonnes/year of sodium chloride from sea-water designed for a site in Australia has been described by Buchanan.[74] The initial concentration is carried out by solar evaporation and is followed by crystallisation in backward feed forced circulation evaporators arranged in triple effect.

Soda

An apparatus patented by Dow Chemical Co.[75] is claimed to produce large, easily filterable crystals of sodium bicarbonate by carbonation of a liquor from electrolytic soda plant. The bicarbonate is calcined to produce soda



Crystals of sodium chlorate



Crystals of anhydrous sodium sulphate

ash. The manufacture of soda ash from Trona through the intermediate stage of refined sodium sesquicarbonate crystals is fully described by Somers.[76] Three *Krystal* crystallisers in series are employed. The final soda ash has a density of 50 lb./cu.ft. and is said to be superior to soda ash produced by the ammonia soda process.

Experiments on the crystallisation of sodium sesquicarbonate both in the laboratory and on a semi-technical scale have been carried out by Pischinger and Tomaszewski.[77] They report that the production rate per unit volume of solution is approximately four and a half times greater when crystallisation is carried out in a vacuum crystalliser than when it is achieved by indirect water cooling.

Henzlik[78] takes advantage of the different settling rates of potassium and sodium bicarbonates to separate potassium carbonate from aqueous solutions containing sodium carbonates. A yield of approximately 90% of 98% potassium carbonate is claimed.

Crystallisation plant

Aoyama[79] has patented a crystalliser with cooling jacket having a vertical agitator without scrapers. It is claimed that by adjusting the speed of agitation to give turbulent flow in the solution it is possible to prevent crystals sticking to the walls of the apparatus. A vacuum crystalliser has been patented by Sagara[80] in which agitation is produced by a waste gas which is introduced into the apparatus and mixed with the solution to be crystallised. Caldwell[81] has outlined current crystallisation theory and practice and gives details of the operating procedures for the draught tube and baffle type of crystalliser. A modification of the draught tube type of apparatus has been patented by Ebner.[82] Saeman[83] has also patented a crystallisation process and apparatus employing the fluidised bed method.

A crystalliser concentrator patented by Schneider[84] consists of two concentric cylinders each having cooling jackets. The solution to be concentrated is passed through the annular space between the two cylinders, where it is agitated by a rotating stirrer provided with special baffles. The baffles are designed to direct the crystals toward the cold walls, which operation is said to favour the formation of large and easily separated crystals. In an apparatus patented by Erbe and Maikowski[85] a melt is passed through a cooled enclosed screw conveyor. Introduced seed crystals are kneaded into the melt and induce a continuous production of small crystals. Mechanical, sonic and supersonic vibrations of varying intensities to induce crystallisation is applied to an apparatus patented by Prietl.[86]

ACKNOWLEDGMENT

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INDUSTRIAL PUBLICATIONS

Flowmeters. A catalogue covering the Fisher & Porter Ltd. range of flowmetering transmitters and secondary indicators, recorders, controllers and integrators has been published. Pneumatic, electric and electronic transmitters for use with variable-area flowrators are described, together with the new differential-pressure transmitter for variable-head flowmetering applications.

Non-destructive testing. An information booklet reviewing site methods of non-destructive testing, including visual welding inspection, X-radiography, gamma radiography, penetrants, ultrasonic flaw detection and magnetic particle inspection has been issued by Solus-Schall Ltd.

Gas scrubber. A leaflet giving details of an improved gas scrubber which is fitted with an agglomerating slot stage can be obtained from Peabody Ltd.

Thermal and acoustic treatment. Available from Stillite Products Ltd. is a revised technical data leaflet No. 22 on *Stillite* mineral wool quilts for thermal and acoustic treatment. This form of insulation consists of a roll of fireproof and vermin-proof mineral wool sewn within a covering of scrim cloth or waterproof kraft paper.

Ultrasonic testing. The new Ultrasonoscope Co. (London) Ltd. catalogue is designed not only to set out the comprehensive range of equipment available but also to be a fundamental reference book for the newcomer to the field of ultrasonic non-destructive testing. More than half the space is devoted to the basic principles of ultrasonic testing and descriptions of some of the techniques used.

Connectors. An illustrated brochure describing a range of connectors is available from the Plessey Co. Ltd. wiring and connectors division. It deals with such aspects of the connectors as the philosophy underlying their design, contact arrangements and wiring procedures as well as giving information about accessory equipment, methods of mounting, special connectors and spares.

High - vacuum continuous crystallisers are the subject of a new illustrated pamphlet recently published by the Kestner Evaporator & Engineering Co. Ltd. In the plant the liquor to be cooled is subjected to a high vacuum in one or more stages, and so is given a flash evaporation.

Chemicals for paints. A brochure describing chemicals for the paint industry has been prepared by Allied Chemicals International. These chemicals are so designed as to impart specific characteristics such as gloss, gloss retention, chemical and solvent resistance, durability or rapid drying for interior and exterior coatings for appliance and industrial applications.

A general chemicals catalogue has been issued by Albright & Wilson (Mfg.) Ltd. An insert section shows the way in which these chemicals are used throughout British industry in the production of industrial and consumer products in everyday use.

Paper coating. *Vinamul* R2912 is an acrylic co-polymer emulsion which has been developed for the paper-coating industry. The incorporation of this into starch or casein-bound coatings is said to pick smoothness, wet-rub resistance, flexibility and varnish hold-out. A report based on experimental work carried out on this product is available from Vinyl Products Ltd.

Molybdenised lubricants. A publication issued recently deals with the applications of Rocol Ltd. molybdenums and lubricants in the many types of equipment in conventional power stations. After listing the applications and recommended lubricants, the publication ends with electrical manufacturers official recommendations.

Looking Back on ACHEMA

By I. L. Hepner, Ph.D., A.M.I.Chem.E.

This year's ACHEMA was outstanding in several respects; above all it provided a vantage point from which to appraise the current state of the European chemical industry. It is felt that it might be judicious to reduce the number of exhibitors at future ACHEMAs in order not to detract from the main aims of this unique exhibition.

THE proverbial man from Mars who arrives on this planet in order to learn about the state of our contemporary chemical industry could well have satisfied his curiosity by spending a very strenuous week at Frankfurt from June 9-17. ACHEMA, which has been described as a European chemical plant exhibition, has by now succeeded in becoming unique throughout the international chemical scene; a recognised forum where new plant is displayed, new processes shown and original research in fundamental and applied chemical engineering discussed. This exhibition could therefore supply any kind of information in any particular sector of chemical engineering and would readily have given our man from Mars a bird's-eye view of chemical and process engineering in the 1960s.

The 1961 ACHEMA was the 13th such exhibition—the first was held in 1920 in Hanover—but this exhibition was definitely the largest ever held, comprising 1,388 exhibitors (only 276 of whom were non-Germans). The exhibits covered 24 exhibition halls equivalent to an area of 900,000 sq.ft. The subject matter covered by the exhibition comprised not only chemical plant, unit operations and stages of chemical processes, but also ancillary, perhaps 'fringe' subjects, such as packaging, accident prevention, laboratory techniques, optics, automation techniques, heavy electrical engineering and nuclear science and technology. Due to the inclusion of these 'fringe' subjects, ACHEMA 1961 took on perhaps a rather elephantine appearance which made it even more difficult to discriminate between those exhibits which were really new and topical and others which were shown only for prestige and advertising purposes. In addition, due to the enormous area of the exhibition, even the most hardy and muscular visitor was soon reduced to a state of extreme physical exhaustion. Almost 100,000 visitors came from 60 countries to visit ACHEMA, another proof of the international significance of this exhibition.

It would certainly be beneficial to the growth and status of future ACHEMAs to prune down the number of exhibitors, especially those showing 'fringe' subjects, in order to assure that the true centre of gravity will be concentrated around chemical plant and processes. There are so many international exhibitions covering the other subjects, such as packaging, automation, etc., that these could more usefully be exhibited elsewhere.

Concurrently with the exhibition, the 30th meeting of the European Federation of Chemical Engineers took place in the form of a congress and presented an opportunity to discuss and survey recent work carried out in chemical engineering research as applied to industrial processes. There were several plenary lectures on subjects of general interest, such as 'Raw material supply in organic chemistry' by Prof. K. Winnacker, and 'Some problems in the kinetics of polymerisation' by Prof. G. V. Schulz. The bulk of papers read at the congress were rather short and were presented to specialised sections. Once again a criticism that could be levied against the organisers is that too many papers were presented (over 100) and that there was consequently insufficient time for discussion. Delegates often left lecture halls with a feeling of mental indigestion; it would be wise if, in future, the number of papers were reduced, allowing more time for comprehensive discussion.

To organise an exhibition and con-

gress of this size is no mean achievement; the fact that, by and large, it ran smoothly and without mishap, is great credit to the organisers, headed by Dr. A. Bretschneider of Dechema, who is really the founding father of ACHEMA. Inevitably, German exhibitors outnumbered foreign exhibitors by a considerable proportion. This gave the opportunity to gain a profound insight into the present state of the German chemical industry (this, by comparison, reflected rather poorly with other countries' exhibits). Nevertheless, the fact must be borne in mind that, despite its European flavour, ACHEMA really is, and will remain, a German - orientated exhibition with some admixture of foreign exhibits. Only 80 British companies made the effort to exhibit at Frankfurt; this lackadaisical approach did very little credit to the British chemical industry and reflected poorly on our avowed aim to increase exports. This is all the more regrettable when it is remembered that this country has belatedly and half-heartedly decided to enter the Common Market. Why was it not possible for the British Government to exhibit selected plant and equipment in a British hall—similar to the two French halls at ACHEMA?

It would not be exaggerated to claim that perhaps 5% of all exhibits shown at major exhibitions are really new developments. In the following review we have tried to select some exhibits which we feel are particularly significant due either to their novelty or improved design.

Continuous extractors and deodorisers

At present a number of different types of extractor are used in industry for the extraction of oil seeds. The *Karussell* extractor (see Fig. 1) exhibited by Extraktionstechnik is a continuously operating plant which operates as follows:

The prepared oil seed flakes are fed into the conveyor and extracted counter-currently. Solvent enters the extractor in the last chamber before discharge. This solvent, having a small oil content, is then pumped into the preceding chamber. There it is enriched with oil and is pumped stepwise counter-currently through the extraction meal for further percolation. Finally, when the solvent has been saturated, it is pumped to a distillation column. The capacities range from 25 to 1,000 tons/day in one plant.

Deodorisation of oils and fats using steam has been common practice for decades. However, this process has always been carried out in batch form. The development of a continuous deodoriser was described and demonstrated by Pintsch Bamag (see Fig. 2). The oil flows into a column divided into several rotating chambers, as shown in the diagram. The path of the oil is through a channel arrangement passing to the outside and from there through a pipe into the next stage. Below the oil layer is a steam chamber with a perforated copper plate to distribute the steam evenly through the oil. Built-in spiral baffles are provided so that all the oil particles have identical retention time in the deodoriser; for example, in a deodoriser having an output of 100 tons/day the path of one oil particle during deodorisation is about 500 ft. Vapours are exhausted through the centre stack, which has an entrance slot in each individual chamber so that the chambers are not parallel with relation to the vacuum and each chamber is kept under the same vacuum.

Drum dryers

For temperature-sensitive solutions, emulsions and suspensions a double-drum spray dryer was exhibited by Escher Wyss. The material to be dried is sprayed on to the surface of the drying drums by means of a number of discs. These drops represent the maximum surface on which the heat can operate from all directions. The rate of drying is thus considerably accelerated and drying is attained after a partial revolution of the drum. The material is then removed by scraper blades which operate below the centre of the drum and are directed downwards. There is therefore no tendency of the dried material to form rolls on the scraper blades. By suitably adjusting the air pressure and speed of the spraying discs the rate of spraying can be adapted within wide limits to the concentration of the liquids to be dried.

By utilising the principle that drying is effected more rapidly if warm air is not blown over a product but sucked through it, Erich Kiefer designed a perforated drum dryer. The plant contains two endless belts which are led over three drums in such a manner that the product during its entire passage through the dryer lies between the belts. The material can easily be spread on to one belt and then distributed evenly. Both belts separate again after the third drum so that the dry product can fall into a bunker. Since the belts are rather wider than the holed width of the drum and the amount of product somewhat narrower than the width of the holes, no product can be sucked in on the edge of each belt. Compared with blowing hot air over material, only a fraction of the drying time is required when using this process.

Size reduction

An air-swept pulveriser that grinds, classifies and conveys material in one operation was shown by Siebtechnik GmbH. This plant is suitable for pulverising and crushing soft to medium-hard material even when moist. An adjustable worm conveys

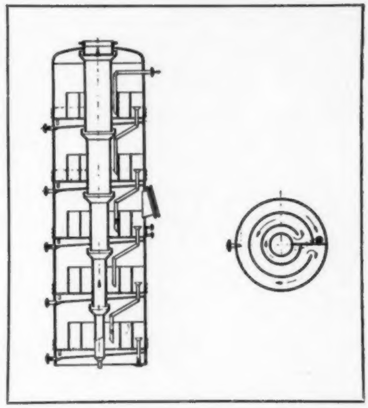


Fig. 2. Continuous deodoriser exhibited by Pintsch Bamag

Fig. 1. Karussell *extractor exhibited by Extraktionstechnik*

Fig. 3. Glitsch ballast tray

pre-crushed material with a quantity of air into the grinding chamber, which houses a rotor. This rotor is equipped with discs whose circumference is fitted with beaters. The classifier plates, which also rotate, are located behind the rotor discs. The ground material arriving at the first rotor disc is thrown against the casing by centrifugal force. Here the material collides with the interchangeable chamber lining. Air passing through the chamber is compressed by the action of the rotor and as this air expands again behind the discs assists the crushing process.

As the material passes through the zone of the rotating discs, the coarser particles are not carried along at the same rate as the finer particles. The former are retained in the pulverising chamber a little longer and during this time they are continuously in contact with the freshly added material and are subjected to further crushing. Finely crushed material is taken from the mill to the cyclone separator and from there to the filter. The air cleaned by the filter is allowed to escape into the open.

Column plates

During the last few years the tendency in the petrochemical and oil refining industry has been to digress from conventional design of distillation column plates in favour of simpler designs which can be installed quicker and have a better corrosion resistance. Gutehoffnungshutte Sterkrade A.G. and Bigurier Schmid-Laurent have specialised in construction of large Glitsch ballast trays.

A Glitsch ballast tray with a diameter of 15 m. was exhibited as shown in Fig. 3. The construction of this tray consists of so many units that it can be assembled and dismantled readily through manholes. These ballast trays have replaced bubble cap trays for many applications, due mainly to their relative cheapness and efficiency. In fact, column diameters can be reduced by 10% when using ballast rather than bubble cap trays.

Filters

Two designs of candle filters with particular advantages were exhibited by Filtres Philippe. One of these filters has perforated tubes made in stainless steel which are covered with a cloth layer and act as filter element. The other type consists of tubes of synthetic porous stoneware. The significant feature of both filters is that they are entirely enclosed and leak-proof. They are perfectly reliable in use, since they can resist any pressure. For that reason they are particularly useful for handling chemicals which require special care.

Glass plant

Q.V.F. Ltd. exhibits included a 40-ft. distillation column, the most striking and visible landmark at the exhibition, a new glass pump, a new type of immersion cooler, magnetic valves, climbing-film evaporators as well as a pulse column designed by Q.V.F.'s German subsidiary, Q.V.F. Glastechnik, of Wiesbaden.

Fans and blowers

An interesting range of blowers, acid-resistant fans and suction plant, as well as dedusting plant and pneumatic conveyors, was exhibited by H. Spelleken Nachf. Kom.-Ges.

Mixers

A new system of powder mixing without mechanical stirring was demonstrated by Gebr. Grun. In this *Airmix* system a batch of material is placed in a vertical vessel and compressed air is admitted at the base of the vessel through a mixing head which filters the air and then admits three short blasts into the main body of the material. The direction of the blasts is so arranged that the fluidised mass is raised rapidly in a vertical spiral motion. Thus the blasts give a folding and mixing action without pressure build-up. The mixing time is generally less than 1 min.

A novel feature of the new *Cowles* dissolver mixers exhibited by Morehouse International Inc. is an improved power transmission system that is capable of delivering over 90% of motor horsepower to the impeller even at lowest speeds, eliminating the necessity of high operation speeds for satisfactory dispersion. An important result is almost instant wetting of highly pigmented mixes.

Stepless speed changes can be made, even during operation. Maximum horsepower can be delivered over a wide range of speeds regardless of changing physical characteristics, such as viscosities, in products being processed. Materials with viscosities up to 50,000 c.p. or more can be easily handled.

Contacting devices

The design of more efficient tower packings is becoming of increasing importance due to the growing number of separation and contacting operations now performed in packed columns. Fuchs-Letchert Sohn demonstrated the *Intalox* saddles which allow a completely random and homogeneous layer formation without impeding the characteristics of the individual packing within the column. Due to the interlocking tendency of individual elements an interlaced internal packing structure results which prevents undesirable movement. The asymmetric form of the saddles prevents formation of nests and channels which interfere with nor-

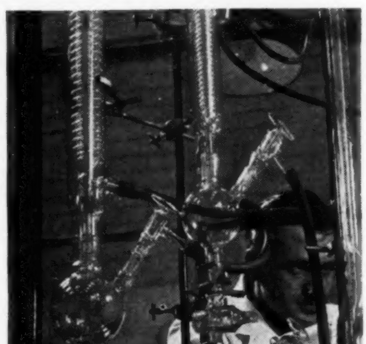


Fig. 4. Laboratory glass plant exhibited by Quickfit & Quartz Ltd.

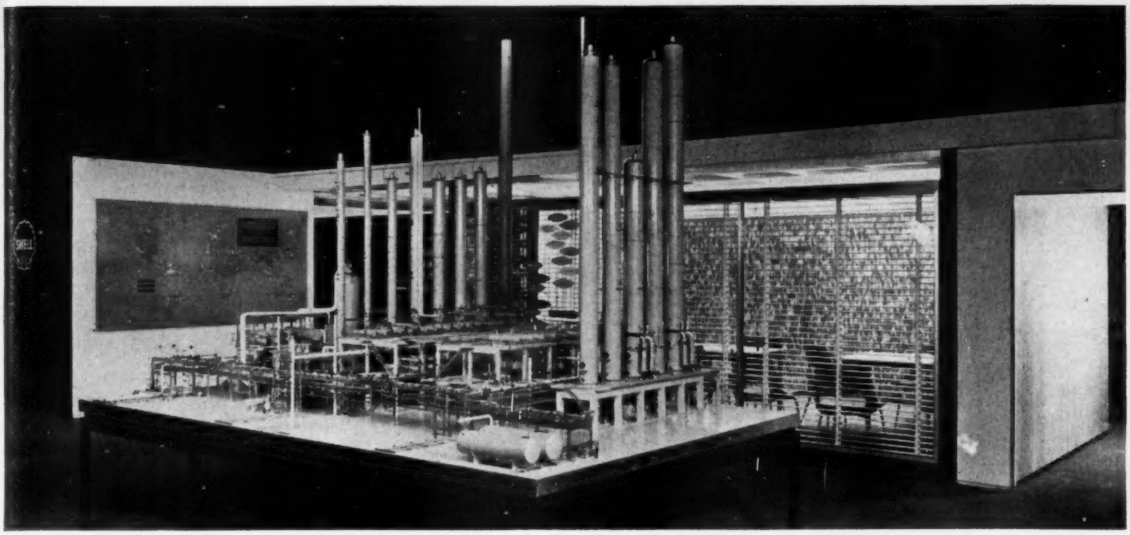


Fig. 5 Model of refinery on stand of Shell International Chemical Co. Ltd.

mal flow pattern. The saddles are made of acid-resistant stoneware with a specific gravity of 2.4 to 2.6.

The wide applications of *Spraypack* packings, which were first developed by the A.E.R.E. for heavy water concentration, is attributed to the particularly good contact that can be achieved with various media. Particular advantages for this packing, which was shown by Dr. Stage-Schmidding-Heckmann, are:

(1) High throughput for steam and liquids.

(2) Very small pressure losses per unit height at maximum throughput.

Thus, at throughputs ranging from 25 to 100% of the maximum, it is possible to achieve optimum rates of mass transfer.

Another type of contacting device that has found particularly wide applications in industry is the *Kittel* plate exhibited by Constructors John Brown Ltd. In any contacting device inserted in a column the gas or vapour undergoes a pressure loss on passing through the liquid. The *Kittel* plate utilises the energy associated with this pressure drop to impart a particular rotational motion to the liquid on the plate. The plate is fabricated from sections of a type of expanded metal arranged as grids covering the cross-section of the column. By suitable orientation of the apertures in these grids, the gas and liquid motion can be directed in any desired way. Standard types of *Kittel* plate consist essentially of two grids—upper and lower. This arrangement results in the liquid flowing down the column being imparted a centrifugal rotational motion on the upper grid and centripetal motion on the lower grid. Thus there are no downcomers in a *Kittel* column; the liquid pours through slots alternatively at the centre and periphery.

New metals

Many manufacturers have specialised in fabricating the rare metals which are of particular importance to the nuclear industry. Heraeus, who are particularly well known in the field of vacuum technology, have devoted special attention to tantalum, niobium and zirconium. During the last few years they developed an electronic melting technique for niobium and tantalum so that these metals can now be obtained by this process in a very high degree of purity. Apart from these better-known metals, the rarer metal europium can now be obtained in large quantities for the first time. Its main advantages are in high surface absorption of thermo neutrons in reactors.

Blending unit

If it were possible to award a prize for the best designed and most informative stand at ACHEMA, this would, in our opinion, have to be awarded to Shell International Chemical Co. Ltd. Inevitably a company as large as Shell has a number of interesting new developments, plant and processes which could be of wider applicability than oil or petrochemical processing. One such plant developed as a result of Shell's interest in blending various oils is the in-line blending plant.

Conventional blending methods consist of mixing components in a tank, but during the last few years this has been replaced by in-line blending, where all components are pumped simultaneously into the common pipeline at controlled rates of flow corresponding to the required proportions of the components in the plant. In order to carefully maintain the ratio between the components, the electronic ratio controller known as *electrorato* has been devised. In a typical in-line blending system exhibited, both flows 1 and 2 are measured by positive displacement meters. The flow rate is translated into an electric pulse signal whose frequency is proportional to the flow. These signals are transmitted to the *electrorato*, which compares the ratio between them with the desired ratio. If the signal ratio differs from the desired ratio a controlled valve is actuated in one of the flows to restore the ratio.

Safety

The work of Dr. Asendorf in the field of the electronic measurement of toxic substances in waste water has been extended to the monitoring of inlet and exhaust air supply. An air sampling device to operate from three to six measuring points represents a new development by means of which even the slightest traces of toxic gases can be detected in working rooms or product pipelines. These appliances respond specifically to prussic acid, phosgene, chlorine gas in phosgene, chlorine, ammonia, hydrogen sulphide, etc. When the concentration of a toxic gas reaches a predetermined level an

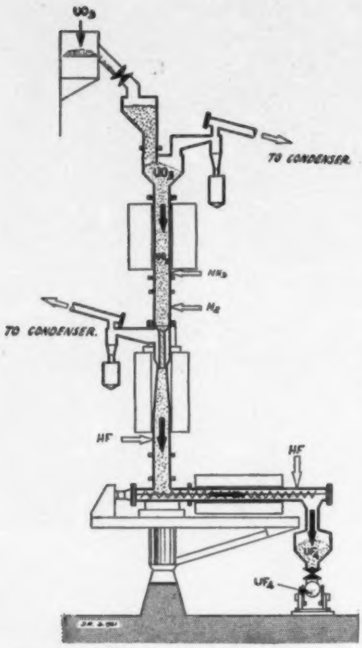


Fig. 7. The reduction hydrofluorination unit exhibited by the Commissariat a l'Energie Atomique

alarm signal is given or some method of control comes into play, such as a ventilation system. Its high degree of accuracy of measurement and the possibility of 'sniffing' gas samples from three or six different points at short intervals of time, gives this appliance a wide range of applications in works control and monitoring of the atmosphere in working rooms.

Disc contactor

A disc or rotary-film contactor was exhibited by the U.K. Atomic Energy Authority. It is designed to permit direct extraction of solutes from slurries and eliminate the heavy expense of liquid-solid separation plant where conventional contactors cannot be used because the solids in a slurry inhibit phase disengagement so that the loss of solvent becomes prohibitive. The contactor unit consists of a vessel containing a horizontal shaft on which are mounted loosely-spaced discs, and this movement maintains in suspension the solids in the slurry occupying the lower third of the vessel. The discs also carry a film of slurry through solvent in the upper part of the vessel, thus transferring the solute.

Prototype disc contactors have been used to recover uranium directly from slurries by counter-current solvent extraction using various solvents, such as tributyl phosphate in kerosene, for nitric acid-leached concentrates. Satisfactory recoveries of uranium have been obtained involving acceptable solvent losses.

Graphite equipment

Société Le Carbone-Lorraine exhibited various items of graphite plant suitable for conditions where highly corrosive conditions exist. Included in the exhibits were a number of *Polybloc* units, some of them cut open to show the internal structure of the passage system. *Polybloc* graphite plant included in an illuminated panel of a pickling plant was also exhibited on the stand of Dr. Otto Saurebau.

Pneumatic conveying

A plant for pneumatic conveying of granulated materials was exhibited by Motor Condensator Co. The material stored in a bin is sucked from there by means of a siphon and then passes into a cyclone separator, where the particles are passed downwards and air and fine-grained particles pass out. This system is suitable for either lifting or circulating materials such as grain, sawdust, sugar, etc.

Surface pyrometer

A temperature measuring instrument based on radiation in the range from 50 C to 250 C was exhibited by Pyro-Werk GmbH. The surface temperature can be determined without contact by holding this instrument near the surface of non-metallic materials in sheet form. The minimum diameter of material to be measured should be about 6 cm. and minimum measuring distance is 1 cm.

Gas cleaning

Gas-cleaning plant was exhibited by O. Falkler & Cie. as shown in Fig. 6. Water and gas are entrained into the chamber by means of a rotor. The dust particles are enveloped by water and the large drops of dust separated from the cleaned air by wooden slats through which the gas mixture passes.

Preparation of UF_4

The highlight of ACHEMA, both as regards compactness and elegance in process design, was the reduction hydrofluorination unit exhibited by the Commissariat à l'Energie Atomique. Hitherto the production of uranium tetrafluoride (UF_4) from uranium trioxide (UO_3) has been carried out in two stages, the first stage involving the reduction of UO_3 to UO_2 by hydrogen or ammonia, and the second stage involving hydrofluorination of UO_2 by anhydrous gaseous hydrogen fluoride. Both in

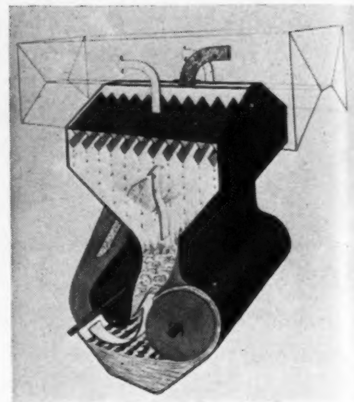


Fig. 6. Gas-cleaning plant exhibited by O. Falkler & Cie

the U.S. and the U.K. these two reactions are carried out separately and in rather complicated plant involving either batch-tray or fluidised reactors. The unit shown at ACHEMA uses the moving two-bed process essentially and makes it possible to carry out these two reactions in a single unit, avoiding the handling of UO_2 in the open atmosphere. Fig. 7 illustrates this as follows:

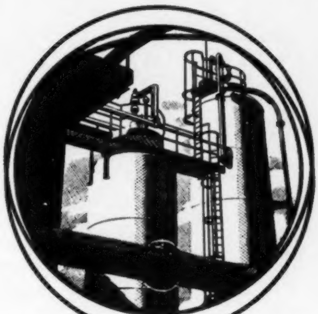
The UO_3 is transformed into a suitable form in order to have gas flow between the solid particles. Reduction in a vertical vessel at a relatively low temperature (600° to 700°C.) is then achieved with gaseous ammonia. By continuous gravity flow the UO_2 passes into the hydrofluorination vessel through a sealed inert gas-lock. Hydrofluorination in this vessel is carried out with anhydrous gaseous HF at 450° to 500°C. and the end of the hydrofluorination is achieved in a horizontal archimidean screw reactor by anhydrous gaseous hydrofluoric acid at 550°C. The retention time of the material is about 5 hr.

Materials handling award

The British Industrial Truck Association continues to foster higher technical standards in materials handling. One of the ways the Association does this is by offering an annual scholarship to enable a selected person to attend a course on materials handling at an advanced level.

The John Morris Memorial Award for 1961 has been won by Mr. William Hollick, senior engineer advising on mechanical handling equipment at Unilever Ltd., for his paper on 'The Design of Warehouse and Storage Areas to allow Efficient Handling by Industrial Trucks'.

Materials of Construction for Chemical Plant



GLASS

By C. Thorpe,* B.Sc.(Tech.)

The sixteenth article in this series is on glass. Previous articles in the series ' Materials of Construction for Chemical Plant ' have included PVC, lead, nickel, stainless steels, graphite, polyolefines, copper, timber, platinum, titanium, aluminium, reinforced plastics, cast iron, mild steel and silver. Only with the introduction of borosilicate glass in the 1920s was it possible to use glass in chemical plant. Due to its excellent resistance to most acids and alkalis this material has become increasingly important to chemical engineers and it is not uncommon nowadays to construct major processing units from glass.

MAN has been making glass for at least 5,000 years and the fact that the museums of the world contain many excellently preserved specimens of these early products is in itself indicative of the chemical stability and resistance to attack of many vitreous materials, at least when they possess the right composition. In more recent times, historically, articles fabricated in glass have occupied a vital place in the laboratories of experimental scientists of all disciplines, and this situation still obtains. With the exception of hydrofluoric acid and some of its derived complex acids, it is possible to use glass for the storage of the whole range of materials from concentrated mineral acids to strongly alkaline solutions over very prolonged periods of time.

It is convenient, at this stage, to point out that the word glass does not describe one material but that it is a term applied to many families of compositions both inorganic and organic. As a result of the wide range of compositions which can be produced in vitreous form, an extremely wide range of chemical and physical properties can be obtained. For example, glasses whose linear coefficients of expansion range over 5 to 150 $\times$ 10^{-7} cm./cm.°C. are used for the production of glass-metal seals in the electronics industry; optical glasses are produced with refractive indices n_D varying from 1.51 to 1.93, and glasses with controlled absorption spectra ranging over 2,000 to 45,000Å are available as filters.

The principal identifying characteristics of vitreous materials are:

(1) That they do not exhibit the usual physical-chemical phenomena associated with the liquid-solid change of state, *i.e.* there is no true melting point.

(2) They are formed by cooling a homogeneous liquid (usually relatively viscous) which on cooling increases in viscosity until, for practical purposes, an elastic solid is obtained. Typical viscosity-temperature curves for a soda - lime - silica, a low - expansion borosilicate and an alumino-silicate glass are given in Fig. 1, whilst Table 1[1] gives details of these three types of glass and some of their properties.

The soda-lime-silica glasses represent by far the greater proportion of current glass manufacture, some of which is used by the chemical industry in the form of containers, *e.g.* carboys, and more recently glass tanks of up to 5,000 gal. capacity constructed from toughened sections of polished plate glass suitably clamped together have become available.

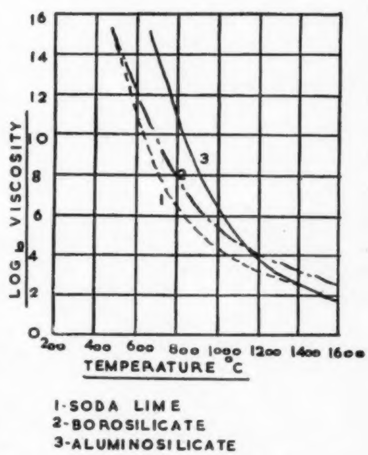


Fig. 1. Viscosity temperature curves for glasses

It was, however, with the introduction of the borosilicate glasses round about 1920 that the stage was set for the increasing use of glass in chemical plant. These glasses have good resistance to corrosion by a wide range of

**The British Glass Industry Research Association, Sheffield.*

materials together with low thermal expansion which contributes both to the preparation of complicated shapes by lampworking techniques (see later) and also their use in processes where stresses resulting from temperature gradients or thermal shock would restrict the use of the soda-lime types. Also their viscosity-temperature characteristic permits higher safe working temperature in any given situation. On this point it is interesting to note that in recent years the increasing severity of operating conditions, particularly working temperature, has led to the development of the aluminosilicate range of glasses. These glasses, which again are of relatively low expansion and good chemical resistance, are being used in specialised electronic applications and as gauge glasses in high-pressure boilers. It is possible that they will also find increasing application as materials of construction for chemical plant where conditions of operation dictate their usage.

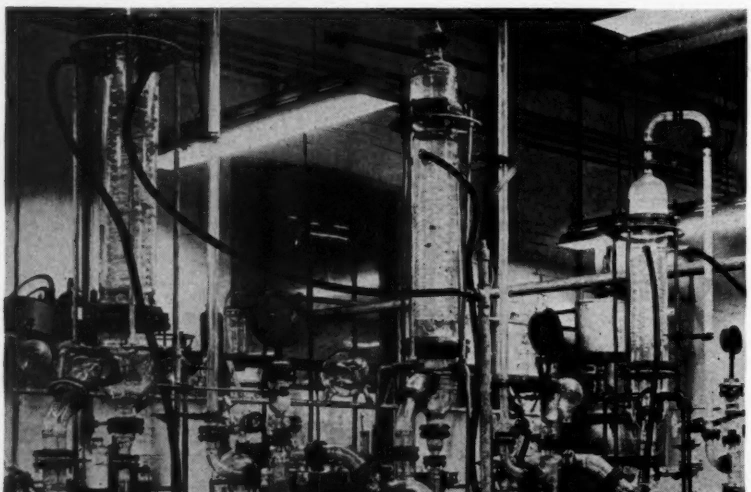
Table I

Type of glass		Soda-lime silica	Borosilicate, low expansion	Alumino-silicate
Composition	SiO_2	70 to 74	80.5	57
	Al_2O_3	0.5 to 1.5	2.2	20.5
	B_2O_3	—	12.9	4.0
	CaO	10 to 13	—	5.5
	MgO		—	12.0
	BaO	—	—	
	Na_2O	13 to 16	3.8	1.0
	K_2O		0.4	
Linear coefficient of thermal expansion, 0° to 300°C.		ca. 85×10^{-7}	32×10^{-7}	$42 \times 10^{-}$
Log vol. resistivity, ohm/cm.: 250°C.		ca. 6.75	8.1	11.4
350°C.		ca. 5.5	6.6	9.4
Young's modulus, p.s.i.		ca. 10×10^6	9.8×10^6	12.7×10

Manufacture of glassware

To some extent the melting and fabrication techniques employed in the glass industry depend on the nature of the end product. In the case of glass equipment for chemical engineering, the bulk of which is made from borosilicate-type glass, tank furnaces operating at temperatures in the region of 1,600°C. and with a capacity of the order of 100 tons are used.

A typical furnace layout[2] consists of two refractory chambers containing glass connected by a submerged channel or throat. The mixture of raw materials, consisting of sand, borax, boric acid and alumina, is continuously fed on by the batch feeders at one end at the same rate at which finished glass is withdrawn from the forehearths for manipulation at the other. During its sojourn in the melting end, the glass is exposed to high-temperature flames directed across the furnace. In order to obtain the high temperatures involved, regeneration of the waste heat in the gases is essential. Under these conditions reactions occur between the raw materials and a silicate melt of about 100 poises viscosity is finally formed which is homogenised and refined, *i.e.* freed from bubbles as it passes along the furnace; the glass then passes through the throat into the refining or working end where its temperature is reduced to give a viscosity of the order of 1,000 poises prior to the forming operation.



[Courtesy: British Drug Houses Ltd.

Fig. 2. General pharmaceutical plant

The primary forming techniques used by the glass industry involve drawing, rolling, blowing and pressing, rolling being principally used in the manufacture of certain types of flat glass which are not of particular interest in the present context. The other three techniques are all used in the production of glass for chemical ware in either hand, mechanically assisted, or fully mechanised methods and in all cases the forming process makes use of the viscosity-temperature characteristic of the material by controlling the rate of heat extraction so that the glass can be made to take up the shape required by viscous flow before being cooled to the solid state. Drawing methods are used for the production of tubing which, in the case of automatic production, is achieved by allowing glass to flow continuously on to a hollow refractory mandrel through which air is blown. The hollow glass tube is drawn off the mandrel by a suitable device. Pressing techniques require a slug or 'gob' of glass of the appropriate weight and temperature to be fed into a mould which is contoured to the external dimensions of the final article, a plunger shaped to the internal dimensions of the article is then used to force the glass into shape. Obviously a limitation of this process is that the plunger must be able to be withdrawn from the article after the pressing operation. Blowing methods use a mould having the external contour of the article into which an envelope of glass can be introduced; compressed air is used to extend the glass until it takes up the shape of the mould.

Using the procedures briefly described above, a wide range of basic shapes of glassware can be provided in a wide range of sizes. These can then be used for the construction of com-

plex units by a process known as lampworking whereby the glass is heated until its viscosity permits distortion, *i.e.* shaping, and, if necessary, the sealing of one piece to another. For instance, straight lengths of mechanically drawn tubing can be bent into spiral shapes which are then sealed together to make a compact cylindrical unit, which in turn can be sealed into a wide-bore thick-walled tube which has standard taper ends thus providing a heat exchanger. Examples of glass plant are shown in Figs. 2, 4, 5 and 10.

Properties of glass

(*a*) *Annealing*

After any forming or lampworking process, glasses must be cooled in a controlled manner through the viscosity range 10^{12} to 10^{15} poises, known as the annealing range, in order to avoid setting up steep temperature gradients in the article. If this situation is allowed to develop, the inner layers will be restrained from shrinking as the general level of temperature decreases and the net result is that severe compressive stresses are set up on the surfaces and severe tensile stresses within. If, however, these temperature gradients are avoided by controlling the rate of cooling until the article has passed through this viscosity range, these stresses are avoided. Above this viscosity, *i.e.* when the glass is behaving as a solid, no permanent thermal stresses can be introduced and it is possible then to cool the glass relatively quickly. This process is known as annealing.

The presence of internal strain in glassware can easily be detected because strain-free glass is optically isotropic whereas strained glass exhibits birefringent effects. Therefore, by introducing the glass sample between crossed Nicol prisms or polaroid sheets, an indication of the optical retardation due to the strain in the article can be obtained. Using more refined optical systems this retardation can be measured and the principal stresses evaluated.

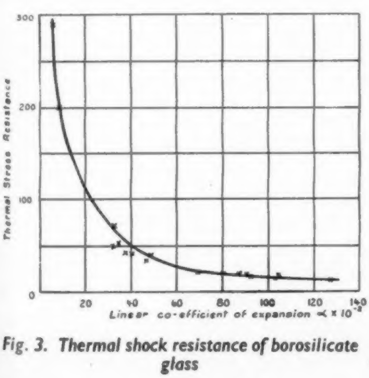


Fig. 3. Thermal shock resistance of borosilicate glass

(*b*) *Thermal shock resistance*

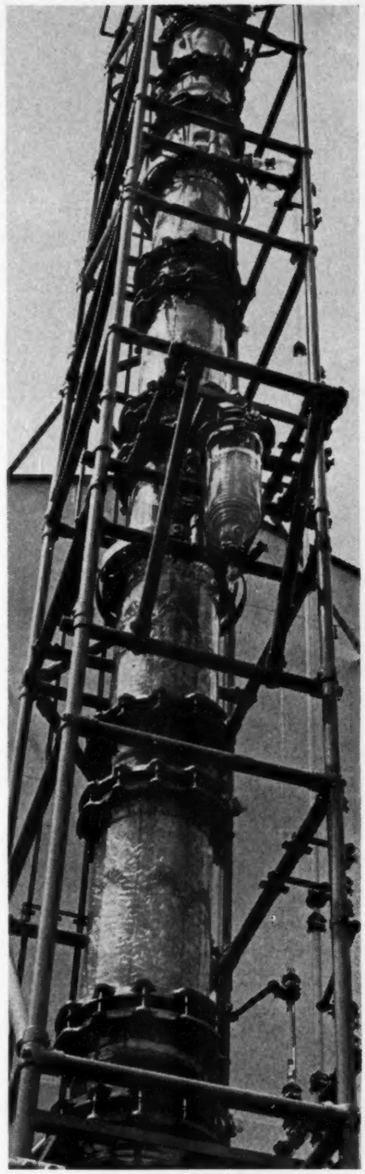
It is well known that glass articles can be broken by thermal shock. If, for example, a container full of hot liquid is plunged into cold water the rapid cooling of the surface layers bring about differential expansion effects which create tensile stresses in the surface and these, if sufficiently large, cause failure. Although the elastic properties and thermal conductivity play a part in this process, it is primarily the thermal expansion characteristic of the glass which determines its performance under these conditions. This effect is shown in Fig. 3, from which it can be seen that the borosilicate glasses, with expansion coefficients of the order of 32×10^{-7} cm./cm.°C. exhibit excellent thermal shock resistance. In this case the data illustrate a test procedure which measures the temperature differential between the two surfaces of a tube or constrained plate that will cause a tensile stress of 1,000 p.s.i. on the cooler surface. It must be borne in mind, however, that shape will have a pronounced effect on the thermal shock behaviour of particular articles and that their performance is dependent on the type of shock administered. If the external surfaces are heated relatively to the rest of the glass, compressive stresses are generated in the surface, whereas if they are chilled, tensile stresses result; poorer performance is usually obtained from the second type situation since the thermally induced tensile forces interact with any flaws in the glass surface resulting from damage in usage, and stress accentuation results.

(*c*) *Thermal conductivity of glass*

A typical figure for the thermal conductivity of borosilicate-type glass is 7.8 B.T.U./W sq.ft.°F./in. (26×10^{-4} c.g.s. units), whereas comparable figures for metals are:

	B.T.U./W. sq.ft.°F./in.
18/8 Stainless steel	110
Lead	240
Cast iron	360
Aluminium	1,440
Copper	2,610

This situation, however, does not preclude the use of glass in heat exchangers where such units are adequately designed. In many cases film resistances to heat flow are as high as, or higher than, the glass wall resistance. Bruce,[4] for example,



[Courtesy: Q.V.F. Ltd.

Fig. 4. 18-in.-diam. fractionating column at Achema Exhibition

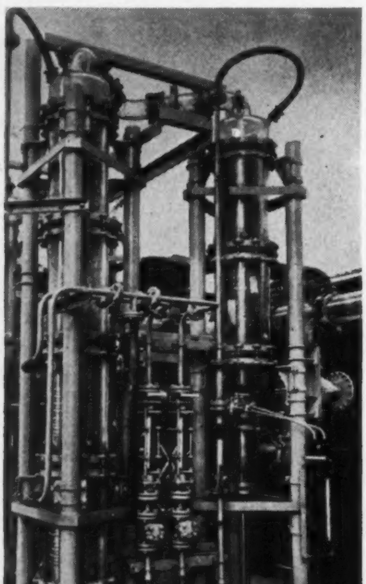
quotes the case of copper and glass condensers constructed to the same specification which, when clean, differed in performance by a factor of 3 : 2½, despite the conductivities of the material being in the ratio 330 : 1. Also, glass does not readily form films of scale or corrosion products which, in the case of metal heat exchangers, can have a marked effect on performance.

(*d*) *Mechanical properties*

Glass is theoretically capable of exhibiting a tensile strength of the

order of 10^6 p.s.i., and recent experimental work has shown that strengths of perhaps half this value can in fact be obtained in the laboratory. However, although this may indicate the direction of possible developments in glass, it is at present more valid to assign a tensile strength of roughly 6,000 p.s.i. to glass in the commonly available commercial forms. From the design point of view, for vessels or apparatus to withstand pressure differentials or other stresses, it is desirable to allow a substantial safety margin and work from a figure of about 1,000 p.s.i. The compressive strength of glass is very high and, practically invariably, glass only breaks under tension. Up to the yield stress, glass behaves as a perfectly elastic solid at ordinary temperatures obeying Hooke's law at least to within the errors of measurement. If stress is applied at high temperatures, for example near the annealing range, then some viscous flow, delayed elastic effects and permanent set can occur.

Characteristically, glasses are brittle solids and in their use this feature requires consideration. It would, for instance, be inappropriate to use glass equipment in a location where it was likely to encounter severe impacts. In



[Courtesy: I.C.I. Ltd.

Fig. 5. Battery of HCl gas absorbers

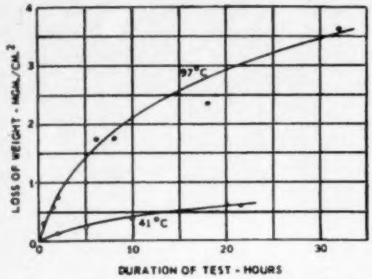


Fig. 6. Solubility of glass of low durability in 5% HCl versus time

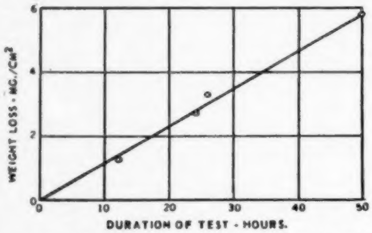


Fig. 7. Solubility of a soda-lime glass in 5% NaOH at 95°C. versus time

the design of pipelines or other equipment, it is possible to use normal engineering assembly techniques provided that suitable gaskets or packings are provided at joints and supports.

Young's modulus of glasses varies to some extent with glass composition but is generally of the order of 10×10^6 p.s.i.

(e) Optical properties

The transmission characteristic for a low-expansion borosilicate glass is given elsewhere[5]. The low absorption in the visible region of the spectrum is of considerable value, enabling the operator to view the inside of a process vessel during operation and also, particularly in applications involving foodstuffs, a direct visual check on cleanliness can be made. In cases where reactions are light sensitive, the near ultra-violet transmission of the glass can be utilised to bring about the reaction; on the other hand, if such reactions are to be avoided, the glass can be permanently stained brown on the outside surface and the ultra-violet transmission eliminated.

(f) Chemical properties

The attack on glass by water or acids is fundamentally different from that by alkaline solutions. In the first case, sodium ions from the glass exchange with hydrogen ions from the acid or water, the process being diffusion controlled, and gradually a hydrated porous layer enriched in silica is built up at the surface through which, for the process to continue, further diffusion must take place. Thus the process is gradually slowed down and with it the rate of removal of material from the glass. This effect is shown in Fig. 6[6] where data for a glass of low chemical resistance not suited for the construction of chemical plant are given.

Alkaline solutions, however, in addition to extracting cations from the glass, also dissolve the porous high-silica layer and, therefore, in these cases continuous solution of the glass occurs when the rates of solution of silica and the other oxides have stabilised. This situation is shown in Fig. 7[6] for a soda-lime-silica glass and the behaviour of low-expansion borosilicate glass with solutions of different pH values is shown in Fig. 8.[7] Fig. 9[8] shows the effect of temperature on the reaction between borosilicate glass and

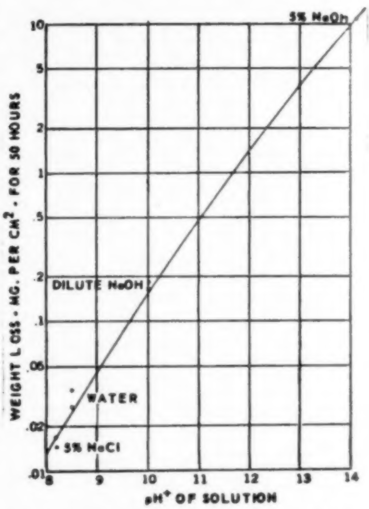


Fig. 8. Durability of low-expansion borosilicate glass versus pH of the reagent at a temperature of 95°C.

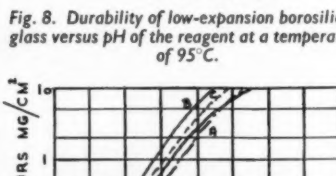


Fig. 9. Solubility of low-expansion borosilicate glass: A—in 1% NaOH; B—in 5% NaOH; C—in 6.9% KOH; D—in 5% Na_2CO_3; E—in distilled water

(Figs. 6, 7, 8, 9 and Table 2 by permission from 'Glass Engineering Handbook', by E. B. Shand. Copyright 1958, McGraw-Hill Book Co. Inc.)

Table 2. Chemical corrosion of glass

Type of reagent	*Temp.*	*Degree of attack*	*Remarks*
Water	To boil.	Negligible	Will not absorb or swell
	150°C.	Loss 0.01 mg./sq.cm., 6 hr.	
	200°C.	Loss 0.13 mg./sq.cm., 6 hr.	
	250°C.	Loss 0.26 mg./sq.cm., 6 hr.	
Sea-water—5% sea salt	Boil.	Loss 0.03 to 0.08 mg./sq.cm., 24 hr.	One year in ocean, no visible effect
Acids:			
HF	All	Severe attack	Not recommended
H_3PO_4	100°C.	21% H_3PO_4, loss 0.005 mg./sq.cm., 24 hr.	Glass satisfactory except at high concentration. Exception, raw acid with fluorides
	100°C.	85% H_3PO_4, loss 0.014 mg./sq.cm., 24 hr.	
5% HCl	100°C.	Loss 0.0045 mg./sq.cm., 24 hr.	
Other inorganic ..	Boil	Negligible	
Organic	Boil	Negligible	
Bases:			
Strong		NaOH KOH, see Fig. 9	
Weak	80°C.	NH_4OH, maximum attack, 3% solution, 0.33 mg./sq.cm., 100 hr.	
Halogens	To 150°C.	Negligible	Dry fluorine questionable
Metal salts:			
Acid	To 150°C.	Negligible	
Neutral	To 150°C.	Negligible	
Basic	100°C.	N/50 Na_2CO_3, loss 0.12 mg./sq.cm., 6 hr.	
	150°C.	5% Na_2CO_3	
Inorganic non-metallic halides	To 150°C.	Negligible	
Sulphur dioxide ..	To 150°C.	Negligible	Fluorides excepted
Ammonia (dry) ..	To 150°C.	Negligible	Slight bloom may appear on surface Ammonium hydroxide, see 'Bases'
Oxidising chemicals ..	To 150°C.	Negligible	
Reducing chemicals ..	To 150°C.	Negligible	
Hydrocarbons	To 150°C.	Negligible	Includes chlorinated hydrocarbons
Amines	To 150°C.	Negligible	Amines with pronounced basic reaction question
Polyhydroxy aliphatics	To 150°C.	Negligible	
Mercaptans	To 150°C.	Negligible	
Oils and fats	To 150°C.	Negligible	

Note.—A weight loss of 1 mg./sq.cm. is equivalent to a depth loss of 0.01 mm./(glass density) or 0.0004 in./(glass density) for those cases where the attack is not selective.

various aqueous solutions, and Table 2[9] indicates the corrosion resistance of this glass to a wide range of reagents. It should, however, be pointed out that, in view of the complexity of the mechanisms involved in the corrosion of glass, it is, in general, desirable to make performance estimates based on data obtained from tests which closely simulate working conditions.

Glass linings and coatings

Although glass has many applications in its own right in the field of chemical engineering, it is not economically feasible to produce very large all-glass equipment and, in addition, mechanical considerations would require such equipment to be treated with great care. However, it is possible to combine the high chemical resistance, non-toxicity, non-flavouring and thermal resistance characteristics of glass with the mechanical strength of metals by applying a coating of glass to the surfaces exposed to corrosive media. In this way large storage, transport and reaction vessels of several thousand gallons capacity can be produced. A variety of metals can be protected in this way, but the most extensive use of the technique is in the production of glass-lined steel equipment.

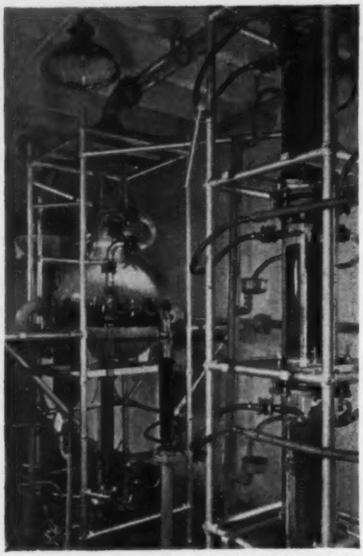
The glasses used in this application are of the borosilicate type but tend to contain more alumina and alkali oxides than the low-expansion composition previously quoted. Also in the glasses used for the first coat on the steel a proportion of cobalt oxide is introduced in order to encourage chemical bonding between the metal and the glass coating. These glasses have a coefficient of thermal expansion of about 100×10^{-7} cm./cm.°C., this figure being deliberately controlled at a value considerably below that of the metal so that in the final article the glass layer is in a state of compression. This situation gives the glass linings improved resistance to thermal shock and mechanical damage.

The production of this type of equipment requires careful specification of the metal used, care in the fabrication techniques involved in making the steel vessel, and thorough cleaning of the metal to be covered prior to coating to remove any scale and provide a roughened surface to aid mechanical keying. The coating is then applied either by dusting dry glass powder on to the heated vessel or spraying a wet milled slip into the cold vessel which, after drying, is heated until the glass fuses. Usually, several applications of glass are made to build up an adequate coating.

With correctly formulated glass such equipment is able to withstand stresses up to the elastic limit of the steel without the lining breaking, and test figures indicate that bond strengths of the order of 5 to 10×10^3 p.s.i. are obtained between the glass and the metal. The thermal shock resis-

Table 3. Corrosion of glassed steel in boiling acid-distilled water systems. Corrosion rates (in. p.a.)

Test solution	*Liquid phase*	*Vapour phase*
Distilled H_2O ..	< 0.001	0.0095
HCl:		
50 p.p.m. ..	< 0.001	0.0064
500 p.p.m. ..	< 0.001	0.0013
1.0% ..	< 0.001	< 0.001
10.0% ..	0.0016	0.0014
14.0% ..	0.0012	0.0031
18.0% ..	< 0.001	0.0052
H_2SO_4:		
50 p.p.m. ..	< 0.001	0.0058
500 p.p.m. ..	< 0.001	0.0017
1.0% ..	< 0.001	< 0.001
10.0% ..	0.0017	< 0.001
20% ..	0.0013	< 0.001



[Courtesy: F. W. Berk Ltd.

Fig. 10. 200 l. vacuum evaporator for corrosive salt solution

Table 4. Corrosion of glassed steel in alkaline media as a function of temperature. Approximate corrosion rates (in. p.a.)

Test solution	80°*F.**	100°*F.*	130°*F.*	150°*F.*	180°*F.*
1% NaOH	0.00045	0.001	0.0035	0.008	0.021
1% Na_3PO_4	0.0004	0.0008	0.0025	0.0045	0.018
1% Na_2CO_3	0.0003	0.0006	0.0018	0.0035	0.012

* Extrapolated using Arrhenius relationship

Table 5

Test solution	*Temperature and time of test*	*Glass under test*	*Corrosion rate (in. p.a.)*	*Estimated life of lining (thickness, 0.036 in.)*
Buffered NaOH, *p*H 11.5 ..	212°F., 30 days	AR	0.012	3 years
		AAR	0.0030	12
½% NaOH solution, *p*H 13 ..	167°F., 30 days	AR	0.046	0.8
		AAR	0.012	3.0
20% HCl solution	Boiling, 30 days	AR	0.00064	56
		AAR	0.00083	43

tance of the vessels is dependent on the operating temperature. As this increases, the compressive stress in the glass resulting from expansion mismatch decreases. Typical figures are: for a vessel operating at 120°C. the maximum recommended thermal shock should be about 93°C.; for a vessel at 205°C. the corresponding figure would be 55°C.

The chemical resistance of glass linings is very similar to that of all-glass equipment. Resistance to water and acids (except hydrofluoric and hot concentrated phosphoric) is very high and organic liquids in general produce no measurable attack. Table 3 gives some of the data reported by D. K. Priest[10] on 15-day tests of a glassed steel both for immersion and vapour-phase conditions in a variety of media.

The attack by alkaline solutions is greater and depends on temperature and concentration as shown in Tables 4 and 5.

Table 4 is again taken from data reported by D. K. Priest[10] and Table 5 gives data from one particular manufacturer for two types of glass from which it can be seen that the AAR formulation, designed for alkali resistance, has very good corrosion resistance to both acid and alkaline solutions and illustrates the point that, in many cases, it is possible to choose a lining formulation suited to the process concerned.

REFERENCES

[1]Data extracted from Tables 1 : 1 and 2 : 1 and Fig. 2 : 1, E. B. Shand, 'Glass Engineering Handbook', McGraw-Hill, 1958.

[2]Reproduced from 'Glass Furnaces and How They Operate', R. W. Spain, *Ceramic Industry*, Aug. 1955, **65** (2), 71.

[3]Data taken from 'Properties of Selected Commercial Glasses', Corning Glass Works, Corning, New York, 1960.

[4]J. McN. Bruce, *Chem. & Ind.*, July 4, 1959, p. 860.

[5]E. B. Shand, 'Glass Engineering Handbook', McGraw-Hill, 1958, p. 65.

[6]*Ibid.*, p. 94.

[7]*Ibid.*, p. 95.

[8]*Ibid.*, p. 97.

[9]*Ibid.*, p. 92.

[10]D. K. Priest, *Bull. Amer. Ceramic Soc.*, 1960, **39** (10), 507-510.

Petrochemicals in Britain

Mr. H. P. Hodge, manager of the Chemicals Division, Esso Petroleum, discusses the petrochemical industry, its achievements and prospects in the August issue of **Petroleum.** Other articles include: Water-Gas Conversion in Today's Technology, by P. W. Sherwood; and Leaders in Oil, 2—Royal Dutch/Shell, by T. H. H. Skeet.

The following articles appearing in our associate journals may be of interest to readers of CPE.

Automation Progress — Introduction to Programming, by B. Girling. Computers in Refinery Technology, by P. W. Sherwood.

Fibres and Plastics — Reinforced Plastics in Chemical Engineering. Polyamide Fibres, 2.

Paint Manufacture — Durability Characteristics of Organic Finishes, by S. K. Bose and S. N. Mukerji.

Manufacturing Chemist — Small-Scale Processing Equipment—Filters, by B. W. Burt. Building a New Chemical Plant.

World Crops — Mechanisation of Small Farms, by J. C. Hawkins.

Dairy Engineering—Expansion of the Soviet Dairy Industry and Equipment Manufacture, by F. Lang.

Food Manufacture—Review of Filtration Equipment and Technique for the Food Industry.

Specimen copies of these journals and subscription forms are available from the Circulation Manager, Leonard Hill House, Eden Street, London, N.W.1.

New department

The University College of Swansea is to institute in the session 1961-62 a one-year course leading to a college diploma in chemical engineering. It will be open to students holding an honours degree, or equivalent qualification, in a branch of physical science or engineering.

The material of construction for chemical plant which will be discussed in next month's issue of CHEMICAL & PROCESS ENGINEERING will be

CERAMICS

Personal Paragraphs

★ M. W. Kellogg Co., a subsidiary of Pullman Inc., have appointed **Dr. Henry B. Hass** as director of chemical research and **Dr. Heinz Heinemann** as manager of research and development. Dr. Hass will direct the activities of the exploratory and research groups of the company and Dr. Heinemann will manage the chemical research and the chemical and mechanical engineering development activities.

Dr. H. B. Hass

★ **Mr. R. G. Huxtable,** M.B.E., is to be the new secretary of the Gas Council. He succeeds **Mr. Wilfrid Bailey,** who becomes deputy chairman of the Southern Gas Board. Mr. Huxtable has been secretary of the South-Eastern Gas Board since 1956 and was previously the Board's solicitor.

★ **Dr. Hans A. Bethe,** nuclear and theoretical physicist and professor of physics at Cornell University, has been named to receive the U.S. Atomic Energy Commission's Enrico Fermi Award for 1961.

★ **Dr. James Burns,** G.M., deputy chairman, North Thames Gas Board, has been elected president of the Institute of Fuel to take office in October 1961. **Sir Harold Hartley,** F.R.S., has been made an honorary member of the Institute.

★ **BTR Industries Ltd.** have appointed **Mr. W. G. B. Mills** as deputy manager of the group's thermoplastics research and development laboratory at Silvertown, and **Mr. G. E. Timms** as chief engineer, also at the Silvertown factory.

★ The appointment is announced of two new directors of I.C.I. Metals Division: **Mr. T. H. Gallie,** who will be overseas director, a new post created to strengthen the sales effort in overseas markets and to co-ordinate the export activities of all Metals Division production units; and **Mr. J. R. H. Crane,** who will be director in charge of copper products.

★ **Mr. E. Jarman** has joined the Council of British Manufacturers of Petroleum Equipment as technical adviser, having relinquished the post of head of the mechanical engineering division of the Kuwait Oil Co., which he has held since 1947, following 31 years' service in the oil industry including 17 years abroad.

★ **Mr. A. A. Round,** assistant general manager of Dunlop's Chemical Products Division, has been re-elected chairman of the technical panel of the British Rubber and Resin Adhesive Manufacturers' Association. Mr. Round joined Dunlop in 1925 as an assistant in the physics laboratory at Fort Dunlop.

★ **General Sir Brian Robertson** has accepted an invitation to join the board of the Dunlop Rubber Co. Ltd. For a number of years he was managing director of the Dunlop subsidiary in South Africa.

★ **Mr. Gerald W. Blakeley, Jr.,** president of Cabot, Cabot & Forbes Co., has been elected to the board of directors, Pennsalt Chemicals Corp. He replaces **Mr. Leonard T. Beale,** who has retired after 38 years' association.

★ **Mr. R. I. Ainslie,** Q.C., and **Mr. N. G. Humphries** have accepted invitations to join the board of Laporte Titanium (Australia) Pty. Ltd. and Mr. Ainslie has been appointed chairman.

★ **Mr. H. R. Brooker** has joined the board of Johnson, Matthey & Co. Ltd. as a joint managing director. He will continue to be principally responsible for all the sales divisions of the company.

Corrosion Exhibition Director to visit New York

Mr. W. G. Norris, director of Leonard Hill Ltd. and Director of the Corrosion and Metal Finishing Exhibition, will visit New York and Washington from October 2 to 20. He will discuss with a number of companies their participation in this international exhibition, the biggest of its kind in the world. Firms requiring first-hand information about the Exhibition should write now to Mr. Norris at Leonard Hill House, Eden Street, London, N.W.1, to arrange a call.

★ **Mr. G. H. Greenhalgh** of the U.K.A.E.A. has been appointed nuclear energy attaché to the U.K. delegation to the European Communities, to succeed **Mr. D. H. Hill.** He will be taking up his appointment in the near future and will act as adviser on nuclear energy matters to the head of the U.K. delegation to the European Communities, keeping in touch with the various installations on the territory of the community concerned with the peaceful uses of nuclear energy. The present nuclear energy attaché, Mr. D. H. Hill, will take up a post with the Authority's reactor group.

★ **Mr. Torsten Berg** has been appointed technical director of A. Johnson & Co. (London) Ltd. He joined the Johnson organisation in 1938 and has been concerned with various aspects of their production and sales of stainless-steel plant and equipment for the food and chemical industries. In addition to his technical work Mr. Berg will continue to be responsible for the company's sale of food and chemical plant.

★ **Mr. R. F. G. Lea,** deputy chairman and joint managing director of CIBA (A.R.L.) Ltd., Duxford, Cambridge, has been appointed a director of CIBA Clayton Ltd., Manchester.

Mr. R. F. G. Lea

★ **Prof. W. Heisenberg** has resigned from CERN's Scientific Policy Committee. A Nobel prize-winner, he has served on the committee since the beginning of CERN. His successor is **Prof. Wolfgang Gentner,** now at the Max-Planck Research Institute in Heidelberg.

★ Shell Research Ltd. announce that **Lord Rothschild,** a director of the company since 1959, has been appointed vice-chairman of the board. In this capacity he will not only continue as a scientific adviser, but will become the company's principal representative in matters relating to academic, government and private research in Britain when the present general manager, **Dr. C. G. Williams,** retires in October. Lord Rothschild is an assistant director of research in the Department of Zoology, Cambridge.

CPE DIARY

AUGUST 15 TO 17 **Cryogenic Engineering** conference sponsored by the University of Michigan in Ann Arbor, Michigan. Details from Chemical Engineering Department, University of Colorado, Boulder, Colorado, U.S.

AUGUST 28 TO SEPTEMBER 1 International **Heat Transfer Conference** to be held at the University of Colorado, U.S. Further details from Institution of Mechanical Engineers, 1 Birdcage Walk, London, S.W.1.

SEPTEMBER 5 TO 15 International **Packaging Exhibition** to be held at Olympia. Details from Press Officer, 34 Victoria Street, London, S.W.1.

SEPTEMBER 6 TO 8 Conference to discuss recent advances in **microwave measurement techniques** to be held at the Institution of Electrical Engineers, Savoy Place, London, W.C.2.

SEPTEMBER 18 TO 21 International Congress of **Food Science and Technology** to be held in London. Details from the Hon. Secretary, International Congress of Food Science and Technology, 14 Belgrave Square, London, S.W.1.

SEPTEMBER 21 TO 22 Conference on **Radio Spectroscopy of Solids** to be held at the University College of North Wales, Bangor. Details from the Institute of Physics, 47 Belgrave Square, London, S.W.1.

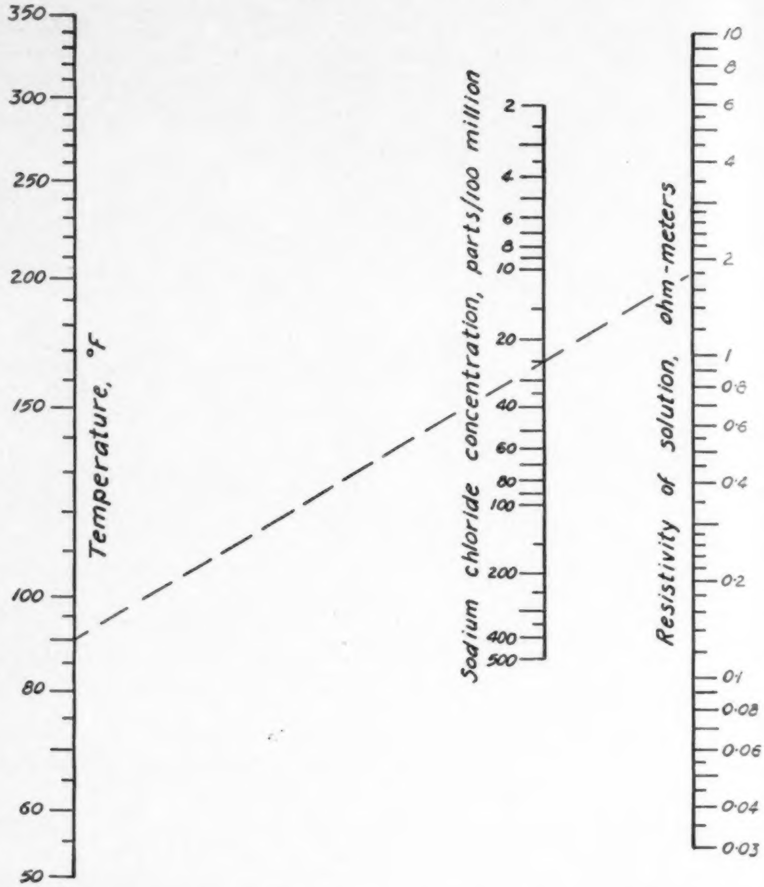
SEPTEMBER 25 TO 29 Eighth annual refresher course on **Current Practice in Fuel Efficiency** to be held at the Clarendon Laboratory, Oxford. Details from the Secretary, N.I.F.E.S., 181 King's Road, Reading.

SEPTEMBER 27 TO OCTOBER 4 International Conference on **Heating, Ventilation and Air Conditioning** to be held at Olympia. Details from Industrial Exhibitions Ltd., 9 Argyll Street, London, W.1.

OCTOBER 3 TO 12 **Electronic Computer Exhibition,** organised jointly by the Electronic Engineering Association and by the Office Appliance and Business Equipment Trade Association, to be held at Olympia.

Resistivity of Sodium Chloride Solutions

By D. S. Davis*



Based on reliable data,[1] the accompanying line co-ordinate chart, constructed in accordance with methods[2] described previously, enables rapid estimation of the concentration of sodium chloride in its aqueous solutions when the resistivity and temperature of the solution are known.

The broken index line shows that the concentration of sodium chloride is 25 parts per 100 million of water when the temperature of the solution is 90°F. and the resistivity is 1.8 ohm-meters.

REFERENCES

[1]D. L. Katz *et al.*, ' Handbook of Natural Gas Engineering ', p. 380, McGraw-Hill Book Co., New York, 1959.

[2]D. S. Davis, ' Nomography and Empirical Equations ', chap. 10, Reinhold Publishing Corporation, New York, 1955.

**Head, Department of Pulp and Paper Technology, University of Alabama.*

Research programmes

In the National Physical Laboratory's report for 1960, pioneering research in a number of important branches of physics is reported, including two new research programmes. One is for research and development on high-speed digital computers, and the second is for a Van de Graaff electrostatic generator and a research reactor, to be sited at Teddington for standards work and for basic research by both the N.P.L. and the N.C.L.

What's New

in Plant • Equipment • Materials • Processes

CPE reference numbers are appended to all items appearing in these pages to make it easy for readers to obtain quickly, and free of charge, full details of any equipment, machinery, materials, processes, etc., in which they are interested. Simply fill in the top postcard attached, giving the appropriate reference number(s), and post it.

Chemical feeder

Fischer & Porter Ltd. are now marketing in Britain their *Micro H. Chemical Feeder* designed to feed, meter and regulate very low flow rates of a chemical solution into a liquid stream through its built-in ejector. Being plastic, the instrument can be used with a wide range of corrosive fluids involving such applications as chlorinating, defoaming, rust and scale inhibition, cooling water treatment, etc. The reagent flow rate is manually set and automatically regulated by an integral differential pressure regulator. **CPE 1696**

Simplified calibration for thermometer

A British bi-metal thermometer, *Zero Re-set*, specially designed so that it can be re-calibrated without a skilled technician, has been produced by the British Rototherm Co. Ltd.

The thermometer has a countersunk instrument and re-set screw. When the screw is removed, two turns of a 2 BA Allen key will loosen the locking screw and allow the thermometer stem to be rotated. This moves the pointer and allows adjustments of up to 50% of the scale range to be made. **CPE 1697**

Power-transmission couplings

A new series of all-metal, flexible, power-transmission couplings, specially designed for light duties and inexpensively priced, is announced by Metaducts Ltd. Called the *Dis* series, the couplings can be used wherever power has to be transmitted in a range from 1 h.p./1,000 r.p.m. to 40 h.p./1,000 r.p.m. or 80 h.p./2,000 r.p.m.

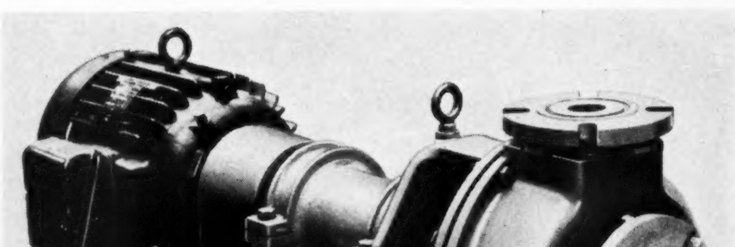
Like the *Metastream* couplings, these have an all-metal construction, no moving parts and minimum maintenance. They will compensate for misalignment and axial deflection and will not transmit thrust. The stacks of stainless-steel discs, each 0.005-in. thick, are riveted together and assembled into an integral membrane unit. **CPE 1698**

Pressure hose

Polypenco Ltd. are marketing a *Nylaflow* pressure hose which is an all-polyamide construction. This medium-pressure, lightweight, non-corrosive hose may be used at continuous working temperatures up to 110°C. and will withstand intermittent use up to 150°C. Stock sizes vary from $\frac{1}{8}$ to $\frac{3}{4}$ in. i.d. in burst pressure ratings of 5,000 p.s.i. upwards. The hose may be used for high-pressure lubrication and pneumatic lines, hydraulic lines, and fuel and oil lines. **CPE 1699**

Computer improvement

Elliott Bros. (London) Ltd. have incorporated into their 803 computer a number of improvements. Operating speeds have been increased, a battery power supply has been built into the system, and temperature is automatically controlled, enabling the machine to operate at ambient temperatures between 50°F. and 110°F. The latest innovation is a paper-tape 'station' grouping together all paper-tape input and output devices, which speeds up the operation. The 803 computer is a fully transistorised machine with an immediate access ferrite-core store of over 4,000 words which can be backed up with four magnetic film storage units giving enormous storage capacity. **CPE 1700**



The Mitchell Craig ceramic-lined pump, designed to handle highly corrosive or abrasive liquors or delicate liquors where metallic contamination must be avoided. Provision is made for removal of impeller without breaking the main suction **CPE 1701**

Continuous filtration

Eimco (G.B.) Ltd. have developed a continuous belt filter known as the *Eimcobelt* filter. It has an endless filter cloth which is constantly removed from the filter surface for cake discharge and cloth cleaning, thus eliminating cloth blinding. As a result, the cloth can be changed in ½ hr. or less, instead of several hours, and minimum cake moisture can be realised. It has a variety of applications including uranium and chromium processing, beet and cane sugar, sewage and industrial wastes, food processing, paper, chemical and fertiliser processing.

CPE 1702

Wet-back package boiler

John Thompson Ltd. are manufacturing the *Multipac* wet-back package boiler for efficient steam raising. It is basically a treble-pass boiler modified to incorporate high-intensity oil burners in small furnace tubes, using a forced-draught system in lieu of induced draught. Refractory lining in the combustion chamber is eliminated and the method of introducing the secondary air supply is said to eliminate ducting and reduce noise. The *Multipac* range comprises 20 models covering an evaporation from 2,000 to 8,500 lb./hr. at 212°F. and suitable for modification, as required.

The *Multipac S.F.* is available for a coal-firing boiler and can be supplied with a stoker ready for coal firing, or with an oil burner with provision for subsequent conversion to coal burning.

CPE 1703

Ultrasonic boiler descaling

Ultrasonic boiler descaling is being used increasingly to maintain boilers in a permanently clean condition. The *Crustex* method of scale prevention, developed by H.N. Electrical Supplies Ltd., consists of a generator which converts mains electricity into direct current of high voltage which is passed into oscillator heads.

The oscillator pulsates at a rate of 28,000 times/sec., which sets up ultrasonic vibrations. These vibrations cause scale formed on heating surfaces to be dislodged in the form of sludge or flakes, much of which is removed from the boiler during blowdown.

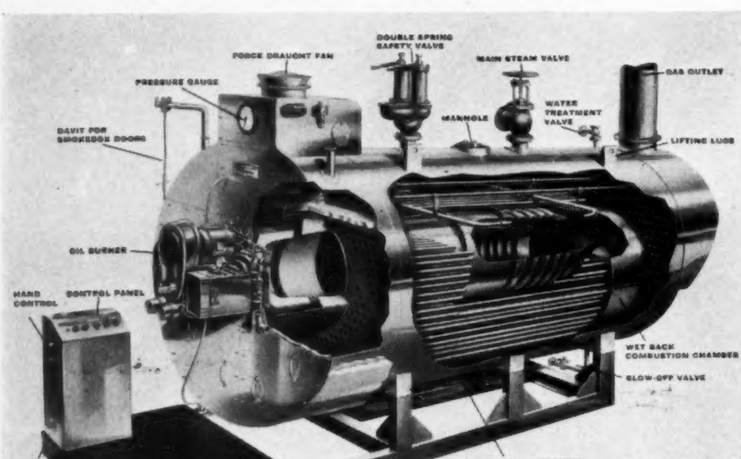
The *Crustex* equipment is long-lasting, current consumption being either 30 or 80 W. The equipment can also be used for removing sulphur crystals after precipitation in a gas scrubbing plant, descaling triple-effect sea-water evaporators, etc.

In an investigation by the Fuel Efficiency Service of the National Coal Board, an analysis of costs was made between ultrasonic descaling and chemical treatment of feed water which revealed that at one colliery a saving of £2,910 was made by using ultrasonic descaling equipment. **CPE 1704**

Laboratory mixer

Silverson Machines Ltd. are marketing their laboratory mixer designed to do the work of the production models on a laboratory or pilot scale. It is in all essentials a facsimile of the larger models, and any results which are obtained with this machine can be reproduced in production, whether pilot or full scale, by the use of larger machines. Its capacity is from 250 c.c. to 8 litres and the motor speed can be varied. It can be raised or lowered on the column or swivelled sideways and upwards towards the operator. It is supplied with the standard head, axial flow head, cutting or disintegrator head and pump head and also with a bench stand. **CPE 1705**

Interior of a boiler before removal of loose scale which has fallen to the bottom



A John Thompson 'Multipac' wet-back package boiler

Economiser

To enable small boiler plants with an evaporative capacity in the 2,000 to 12,000-lb./hr. range to benefit from the installation of an economiser, Green & Son Ltd. of Wakefield have introduced the *Unicon*, a compact design in the form of a self-contained shop-assembled unit, completely cased and insulated, with dampers and duct connections. Placed into position and installed between boiler and induced-draught fan, the *Unicon* can afford maximum performance in minimum space.

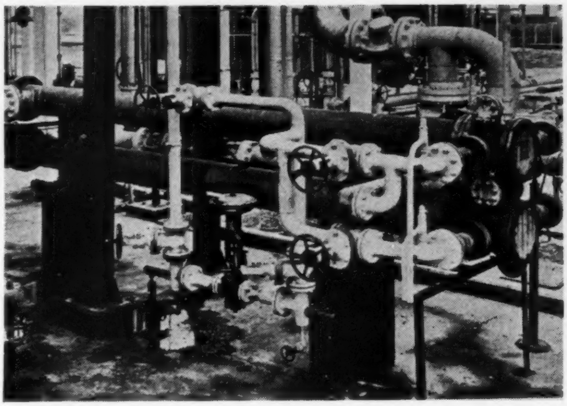
Four sizes of the *Unicon* unit economiser are available with 12, 16, 18 and 24 tubes, giving heating surfaces of 504, 739, 832 and 1,109 sq. ft. respectively, designed to suit most boilers with pressures up to 650 p.s.i. and evaporative ratings up to 10,000 lb./hr. **CPE 1706**

Corrosion measurement

The *Corrosometer*, marketed by Winston Electronics Ltd., Middlesex, on behalf of the Crest Instrument Co., California, U.S., measures corrosion

in the laboratory, process and storage plants by giving a swift direct reading of the corrosion rate in less than a minute. By using this instrument and its probes the efficiency of anti-corrosion methods may be ascertained and also remedial action may be carried out at the appropriate time.

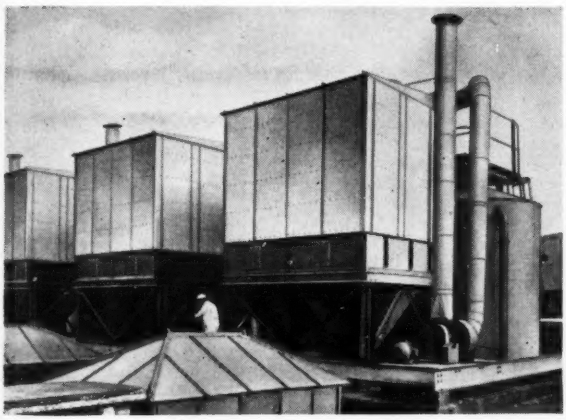
The reading from the probe is in micro-inches or centimetres on the meter without removal of the specimen. The *Corrosometer* can be used for all metals and alloys.
CPE 1707



An all-aluminium heat exchanger installed in the gas purification plant of Mobil Oil Co.'s refinery at Coryton and made by Wellington Tube Works Ltd., incorporates internally clad tubes made by Alcan Industries Ltd. The unit has been found to resist attack by hydrocarbon gas and by corrosive Thames estuary water **CPE 1713**

Stainless-steel pipe fabrication

Welding Technical Services Ltd. are making spirally welded pipe in stainless and nickel alloy steels. The strength of the new pipe is due to the spiral formation which, since the joint is at an angle to the stresses at the circumference, subjects the seam to only a fraction of the full tensile force. The additional strength means that lighter-gauge metals may be used. This technique is combined with the existing *Weltexa* method of prefabricating complete installations from standard parts, to bring down the cost and add ease of installation. **CPE 1709**



Three Dallow Lambert 'Drytube' dust filters, each capable of handling 2,700 cu. ft./min. of air. The filters have 1,000 sq. ft. of nylon filter-bag area with automatic shaking gear, enabling the sleeves to be cleaned whilst the fan is in operation. Each fan is powered by a $7\frac{1}{2}$-h.p. motor and the collected dust is fed back into the product-handling system by means of discharge ducts from the filter hoppers **CPE 1708**

Aluminium alloy tube

Imperial Aluminium Co. Ltd. are now marketing *Unitrace* tube in the U.K. This is designed for use in the processing of chemical and food products where liquids must be kept warm to prevent solidifying when being pumped from one location to another. It is equally effective where liquids have to be kept cool at a controlled temperature.

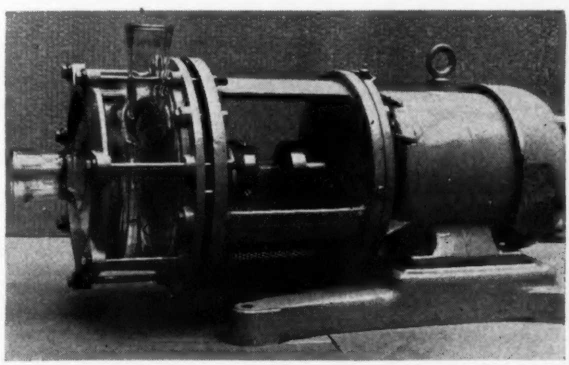
This tube is supplied in standard 30-ft. lengths and in seven standard sizes from 1 to 8 in. **CPE 1710**

Domestic water meter

George Kent Ltd. have announced an ebonite working chamber version of their brass $\frac{1}{2}$-in. JSM domestic water meter. The new meter, which is to be known as the Kent $\frac{1}{2}$-in. SM, incorporates all the features of the Kent JSM rotary-piston-type meter and may be used where the water supply tends to be corrosive.

It is expected that $\frac{3}{4}$-in. and 1-in. versions will be introduced later.
CPE 1711

A glass pump, model GPB, made by QVF Ltd., is designed to provide an efficient unit in which the chemical- and shock-resistant qualities of borosilicate glass are applied to conveyance of corrosive liquids. It is of centrifugal type, running at 1,400 rev./min. and is available in two sizes **CPE 1712**



Storage feeder

At the Interplas Exhibition, Gardner & Sons (Gloucester) Ltd. exhibited a bunker and belt feeder, the latest addition to their storage range. This unit can store such materials as damp granulated products and feed them at a predetermined rate. Constant volumetric or weight feeding is achieved by fitting a weigher unit to the feeding belt and a feed-back system controls a device which governs the thickness of the carpet on the belt. The bunker contains a slow-running agitator and the feeder belt works in conjunction with an adjustable rotating trimmer, the height of which is governed by signals from the weigher mechanism.
CPE 1714

Molten sulphur

Molten sulphur is distributed and transported in specially designed road tankers by F. W. Berk & Co. Ltd. Some of the advantages of delivering sulphur in a molten state are freedom from dust, elimination of contamination, reduced fire risk and corrosion losses, and the heat required to keep the molten sulphur ready for use is less than that required to melt a similar quantity of powdered sulphur.
CPE 1715

Nuclear Notes

Swedish investigation

Westinghouse Electric International Co. have announced an agreement with A. Johnson Co. of Stockholm and the Bechtel Corporation of San Francisco to conduct a joint technical study for AB Atomenergi, the Swedish Atomic Energy Authority. The study involves evaluation of a pressurised heavy-water reactor (P.H.W.R.) with a capacity of 250,000 kW, scheduled to be completed in eight months.

Spent reactor fuel

The Atomic Energy Commission has designated its Savannah river plant in South Carolina and its chemical processing plant in Idaho as the A.E.C. facilities which will receive spent fuels from the U.S. and foreign nuclear reactors.

Uranium fuel purification

An experimental plant for cleansing used uranium fuel, jointly operated by the Norwegian Atomic Institute and the Reactor Centre, Netherlands, was dedicated recently at Kjeller, near Oslo. The fully automated Dutch-Norwegian plant is operated by remote control to minimise radiation hazards. The cleansing plant will be connected with a project for treatment of radioactive waste, now under construction.

The rig flask of PLUTO, high flux material reactor, at the U.K.A.E.A.'s Research Establishment, Harwell. It is used to lower the experiment into the reactor

Automatic thermocouples

Instrument engineers of the U.K. A.E.A. have devised and patented a thermocouple system which makes the thermocouple retractable. This allows it to register temperatures in vacuum apparatus used for reactive metals.

Irradiated fuel plant

The Eurochemic Co. is to begin construction on its plant for the chemical processing of irradiated fuel at Mol in Belgium. The plant will have a capacity of 350 kg./day for natural uranium elements, or 200-250 kg./day for enrichments up to about 5%, and will accept a wide range of fuels.

Assistance for Turkey

A leading American expert, Dr. R. L. Doan, is to advise the Turkish Government on atomic energy planning. The services of Dr. Doan have been made available under the International Atomic Energy Agency's programme of technical assistance.

Superconductor material

A new superconductor material which offers no resistance to electrical current has been developed by Atomics International under a research contract with the A.E.C.

U.K.-Euratom co-operation

Foreseeing the increasing need for nuclear power towards the end of the present decade, Euratom have created optimum conditions for this challenge to be met, believing that nuclear power would become fully competitive around 1970. They expect that by 1980 the Community will have about 40,000 MW of nuclear power generating capacity. They are now moving towards a more realistic working partnership with the U.K.

Enriched uranium fuel

The PM-2A's enriched uranium fuel will take the place of more than 850,000 gal. of diesel fuel which would be required annually by a conventional power plant. This polar base, built to accommodate a team of approximately 100 Army research personnel, receives its supplies entirely by air or sled.

The PM-2A is skid-mounted and air-transportable, so that it may be dismantled and shipped by large cargo plane to another site if necessary. It was prefabricated and tested at Alco's Dunkirk, N.Y., plant before being shipped to Greenland last summer.

Reactors in Japan

General Electric Japan Ltd. have signed a contract to furnish a critical assembly reactor for the Japan Atomic Energy Research Institute (J.A.E.R.I.). U.S. General Electric, of which General Electric Japan is a subsidiary, will design the reactor and fabricate the nuclear fuel.

The reactor will be a light-water-moderated critical assembly utilising uranium dioxide fuel enriched 2.6% with U^{235} and clad in aluminium. Scheduled for completion in July 1962, it will be located at Tokai Mura and will be used in experiments to provide nuclear data for the design and evaluation of light-water-moderated and cooled reactor cores.

G.E. Japan have also received an order for six additional in-core flux monitoring systems for the 12,500-kW (electrical) power demonstration reactor at Tokai Mura. Major construction on this reactor, expected to generate the first atomic-electric power in the Far East, is scheduled for completion in 1963.

Turkey at C.E.R.N.

With a view to furthering scientific co-operation with Turkey and to keep this country generally informed about the fundamental nuclear research work of C.E.R.N., the Council of C.E.R.N. have invited the Government of Turkey to send an observer to its sessions.

Boiling water nuclear power plants

It is now thought that large-scale boiling-water nuclear power plants can be built to compete with fossil-fuelled power stations in favourable sites. High-power density nuclear cores (in the range of 35 to 40 kW/litre) can now be designed which will permit construction of 400,000 and 500,000-kW BWR plants with reactors and

containment physically no larger than that of the 184,000-kW Dresden station. A plant could be built for start-up in 1965 at a cost of about \$175 (£63)/installed kW, and power from such a plant would be comparable to that produced conventionally in areas of high fuel costs.

U.K.A.E.A. team in Australia

Three men from the U.K.A.E.A. have been to Sydney for discussions with the Australian A.E.C. on research co-operation. Before construction of the research establishment at Lucas Heights was begun in 1955, close co-operation had already been established and a team of Commission scientists worked on the Australian research programme at Harwell and other establishments of the Authority. The Commission is undertaking several research contracts for the Authority, involving irradiation of beryllium and uranium in the Lucas Heights reactor HIFAR.

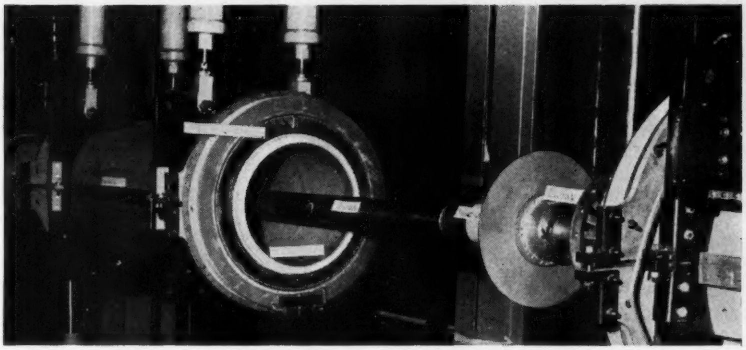
A miniature plasma sun photographed in one ten-millionth of a second

Plasma miniature sun

A miniature sun created by a plasma pinch and heated to several hundred thousand degrees, is the result of an experiment of the controlled thermonuclear research programme jointly sponsored by Texas Atomic Energy Research Foundation and General Dynamics Corp.'s General Atomic Division. High-speed photographs reveal plasma instabilities which previously could only be inferred by other diagnostic and theoretical methods. This will eventually make possible controlled fusion reactions, when means have been found to eliminate the instabilities.

Nuclear fuel elements

Development of a method of fabricating nuclear fuel elements at reduced costs is announced by the Babcock & Wilcox Co. It involves the vibration of UO_2 powder into thin hollow rods which are forged to the final diameter, the powder being compressed to the required density.



A stability experiment at the U.K.A.E.A. Research Establishment, Harwell. The equipment is used for the study of a pinched discharge

Fuel core

The nuclear power core—valued at \$22,000,000—for the atomic electric generating station being built by the Consolidated Edison Co., New York, has achieved its first sustained chain reaction at the Babcock & Wilcox Co.'s Atomic Energy Division laboratory.

German power plant

Berliner Kraft und Licht (B.E.W.A.G.) A.G., the electric utility serving West Berlin, has engaged three companies—two U.S. and one German—to conduct a closed-cycle water reactor study for a 151,000-kW net nuclear power plant for that city.

Nuclear tests for Germany

A contract to conduct tests of nuclear materials for Siemens-Schuckertwerke A.G., of Erlangen, Germany, is announced by Westinghouse Electric International Co. The tests will be conducted at the Westinghouse testing reactor in Waltz Mill, Pennsylvania.

NORA

The new zero energy facility NORA at the Institutt for Atomenergi (I.F.A.), Norway, is now in operation. It will establish various reactor physics data for the development of power-producing reactors.

£ s d

CHEMICAL PLANT COSTS

Cost indices for the month of June 1961 are as follows:

Plant Construction Index: 184.9

Equipment Cost Index: 173.9

(June 1949 = 100)

£ s d

Heavy water for reactor

Canada has purchased 169,500 lb. of heavy water from the U.S. for use in its natural uranium-fuelled, heavy water moderated power reactor programme.

Nuclear reactor cartridges

The Board of Trade have given notice that they are considering an application for the removal of the import duty on nuclear reactor cartridges, spent or irradiated, falling under tariff heading 28.50(B).

A statement of the applicant's case will be made available to all firms and organisations with a *bona fide* interest in these materials who wish to make representations in the matter, if they are prepared to give an undertaking to treat the information contained therein as strictly confidential and to allow their comments to be passed to the applicant for reply.

European pulp and paper market

The European pulp and paper market (O.E.E.C. countries and Finland) achieved a remarkable expansion in 1960. This is shown by the survey of market trends made by the O.E.E.C. Pulp and Paper Committee. New records have been set up in Europe (an increase of 12% in the production and 13% in the apparent consumption of paper and paperboard; an increase of 12% in the production and 15.9% in the apparent consumption of wood pulp as compared with 1959).

Demand continues strong at the present time and this suggests that, on the whole, existing production capacity will be fully taken up in 1960. Activity in the sector may no doubt still increase in 1961 at an overall rate in excess of 5%, although this rate is likely to be lower than in 1960.

New Books

17th International Congress of Pure and Applied Chemistry. 1960. Vol. 1: Inorganic Chemistry, 63s. net. Vol. 2: Biochemistry and Applied Chemistry, 75s. net.

These consist of a collection of the papers presented at the congress held at Munich from August 30 to September 6, 1959.

Volume I consists of research papers on topics connected with inorganic chemistry, whilst Volume II covers topics connected with the chemistry of naturally occurring materials and the applications of this. Although the majority of the articles are in English many of the sections are in German or French and this gives rise to some difficulty, particularly in Section A5 on super-purity metals where the only articles are in German and French.

Volume I opens with a collection of lectures from schools in Russia, America, England, Austria and France dealing with the present position in the research project with which the school is engaged. The standard of these is uniformly high as can be judged by the paper by Prof. Emeleus on compounds of fluorocarbon radicals with metals and non-metals, though the topics themselves are of specific interest to the school concerned, as witness the references mainly to the author's own school, though the methods and theoretical conclusions are of much wider interest.

The remaining papers are listed in Sections; Section 1 being concerned with compounds with metal carbon bonds; Section 2, hydride chemistry; Section 3, actinides and lanthinides; Section 4, fluorine and fluoride chemistry; Section 5, super-purity metals; Section 6, water-like solvents; Section 7, homogeneous and heterogeneous gas equilibria; Section 8, semiconductors and compounds of semi-metals; Section 9, ternary oxides and sulphides; Section 10, abstracting and indexing with the electronic computer.

These sections cover a very wide field, although it is curious that the two papers on super-purity metals give so little reference to contributions in the English language on this very important subject, the second paper (French) quoting only French sources of information on zone refining. It is interesting to speculate on the amount of information which might be neglected due to this being in a less-familiar language and, therefore, ignored, in the mass of more easily obtainable material.

Volume II opens with two sections on biochemical topics: Section 1 on natural pigments and Section 2 on the synthesis of some important oligopeptides, and then proceeds to the symposia on applied chemistry. The three sections in this symposia all deal with topics of very great interest at the present time. Section 1, on reactions at ultra-high pressure, provides a useful résumé of a field in which research work in England has tended to lag; but with the announcement of the acquisition of facilities for this work by the National Physical Laboratory, it is hoped that this may be quickly rectified. It is particularly interesting to note the methods described on p. 169 for the calibration of pressure by the use of the varying resistance with pressure of certain metals and their reference transition points as determined by the pioneer in this work, P. W. Bridgman.

The remaining sections all deal with the research aspect of various problems of the day, such as the disposal of radioactive residues and the effects of food additives, pesticide chemicals and their effects on human and animal feedstuffs. It is extremely difficult to critically review the range of topics covered by these two volumes at this highly academic level.

The text is extremely well produced and arranged. There is, of course, no index other than chapter headings and, although carrying the publisher's name of Butterworths, the printing has been done in Germany and the format and graphs have a Continental flavour.

F. Molyneux

Chemical Processing of Fuels: Selected Papers from Proceedings of the Second All-Union Conference on Artificial Liquid Fuel and Gases. The Israel Programme for Scientific Translations, 1960. Pp. 110. 35s. net.

This volume is another welcome addition to the growing range of Russian scientific and technical literature at present translated into the English language. A recently formed Israeli translation service undertook this translation for the National Science Foundation, Washington.

As the title suggests, all the papers included deal with various aspects of chemical, *viz.* low-temperature processing of fuels. It is important to appreciate the difference in composition between such low-temperature tars and petroleum crudes on the one hand and coke-oven tars on the other. The two introductory papers discuss scientific research carried out at present in the U.S.S.R. in this field. Other papers deal with particular techniques such as carbonisation in fluidised beds, carbonisation under pressure, effect of thermal treatment on yield, hydrogenation and decomposition of hydrocarbons in the presence of a catalyst, thermal dissolution of fuels and gasification of fuels by removal of liquid slags.

As the authors of the introductory paper have immediately pointed out, enormous amounts of gases and tars are wasted each year by burning solid fuels. Despite this, most industrialised countries have made attempts to extract tars and gases—but with differing efficiencies. A fundamental obstacle to low-temperature carbonisation is the disparity between the capacity of existing installations for low-temperature coking and the large number of coal or coke-fired power plants—the largest Soviet plant for low-temperature carbonisation is in Estonia where Baltic bituminous shale is used as raw material. From the chemical engineering point of view the most interesting development reported is that of low-temperature carbonisation in a fluidised bed. The advantages of this technique include steady temperature conditions and improved heat transfer—several plants based on this process already exist in the Soviet Union.

The subject matter discussed in this volume is of undoubted interest to anyone connected with the fuel industry since it gives a broad insight into present-day thinking of Soviet fuel planners. Nevertheless, the presenta-

tion of this book leaves much to be desired. The translation is poor and unidiomatic; copious editing of Russian texts could have eliminated needless rhetorical repetitions. Besides this the plentiful spelling mistakes, especially of chemical nomenclature, give the impression that the translators had very little idea of the general background which they were translating. It must be hoped that future translations of such papers, which are keenly appreciated by English-speaking technologists, will be prepared with greater care.

I.L.H.

Separation Processes in Practice. Edited by Robert F. Chapman. Reinhold Publishing Corporation, New York, 1961. Pp. v + 209 (without index), illustrated. 40s.

This book contains a collection of seven papers presented in Philadelphia under the auspices of the American Institute of Chemical Engineers and the School of Chemical Engineering, University of Pennsylvania.

The initial chapter entitled ' Fundamentals of Mass Transfer Processes ' contains a useful summary of the penetration theory of gas absorption together with brief accounts of the mixing characteristics of packed beds and mass transfer in spray towers. This is followed by ' Fundamentals in the Design of Liquid Extraction Processes '. There is also a paper dealing authoritatively with the separation of aromatics and paraffins by solvent extraction. The only other conventional unit operations which are discussed are crystallisation, in relation to continuous processes, and distillation. The latter is, however, confined to a descriptive account of different types of tray devices. No attempt is made to assess the relative merits of these devices in terms of efficiency or capacity; the reader is, however, referred to manufacturers' publications for such data.

The other two chapters in this book draw attention to two rapidly developing new fields. Ion exchange is considered, somewhat refreshingly, from a mass-transfer point of view. In particular the generalised correlation of packed-bed mass-transfer data based on the *j*-factor concept and Carberry's boundary layer model are most valuable. The other chapter is devoted to 'a preliminary evaluation of electric membrane processes for chemical processing applications '. It is the most informative paper presented at this meeting and includes a considerable amount of practical information together with a discussion of the cost of facilities and equipment.

Summing up, the volume is informative, stimulating and thought-provoking. It suffers, however, from the grave defect that non-American sources of literature are almost entirely neglected. Although the preface implies that the main aim has been to supply practical information for the young engineer, the book is particularly suitable for engineers wishing to keep up with new developments. The book deserves a wider circulation than the price will inevitably allow.

S. D. Holdsworth

Bezugsquellenverzeichnis der Atomwirtschaft (Buyers' Guide—Nuclear Industry in Germany). Econ Verlag G.m.b.H., Düsseldorf. Pp. 127. $3.50.

The peaceful uses of nuclear energy have fired the imagination of the nations and have provided a powerful ' shot in the arm ' to many branches of industry. German industrialists have not been slow to react, and have made a really admirable effort to secure a leading place among the suppliers of the innumerable items of materials and equipment for this healthy new technology. In several important fields the international standards of nuclear technology have been reached and, in a certain number of specialised spheres, German firms justifiably claim a lead.

Econ Verlag has now published the first comprehensive buyers' guide to the German nuclear industry, at least as applicable to Western Germany. It lists over 300 firms which are specialising in nuclear products, trading in such items or offering services in this field. The products cover over 250 items, ranging from accelerators, adsorbers, and air and water monitoring plants to ship propulsing (*sic!*) reactors, waste disposal and reactor quality welding.

This buyers' guide is edited by W. D. Müller and R. Hossner, both on the staff of the well-known journal, *Die Atomwirtschaft*, and this ensures both adequate and authoritative entries and presentation. One particularly useful feature of this 127-page book is the fact that it is bilingual. While one must not under-rate the importance of German efforts in nuclear technology, one must be also realistic. Undoubtedly English is the *lingua franca* of the atomic world, and every nation has freely adopted from nuclear scientists and engineers the specialist vocabulary of the Anglo-Saxon peoples. The editors are to be congratulated on having had the foresight to include English translations of all the entries. Their long experience in the field of nuclear energy has been amplified by the replies to a questionnaire which was sent to all industrial undertakings in Western Germany likely to offer information coming within the scope of the buyers' guide.

The several misprints, grammatical oddities and Americanised spellings, do not, I think, detract at all from a very valuable publication. This book contains a mine of information, and it should be a great help to all those engaged in planning, development, building and consulting within the field of nuclear technology. The book is clearly printed and of convenient size for carrying in the pocket.

F. R. Paulsen

Chemicals. The 94 organic and inorganic chemicals produced by Hooker Chemical Corporation for industry and agriculture are reviewed in a newly revised and enlarged leaflet.

Portable air compressors. In leaflet CB 195, issued by B.E.N. Patents Ltd., a wide range of portable air compressors is illustrated, together with supporting data on performance, pressure and h.p. requirements.

SEPTEMBER ISSUE OF CPE

Some articles in next month's issue of particular interest to our readers are:

- Desalination of water
- Design of flash evaporators
- 'Aquaflash' desalination plant
- Materials of Construction for Chemical Plant: Ceramics

Chemical Engineering Congress

An international symposium on ' The Physics and Chemistry of High Pressures ' will take place at Olympia during the third congress of the European Federation of Chemical Engineering. Among many subjects to be discussed are: process optimisation, interaction between fluids and particles, and a symposium on 'The Handling of Solids'. The date will be 26-28 June, 1962.

CPE Company News

New filling stations

The Calor Gas (Distributing) Co. Ltd.'s new filling station at Neath (Glamorgan), one of three now under construction, is due to come on stream in September. It has a design capacity of 10,000 tons p.a. based on a 250 8-hr. working day. Neath's sister plants, at Ellesmere Port (Cheshire) and Grangemouth (Stirlingshire), both of similar design capacity, are expected to be operating by the end of this year and next spring respectively.

This development programme, involving an estimated expenditure of £1.5 million, reflects last year's increases in the consumption of *Calor* propane and butane liquefied petroleum gases.

Electronic filling methods are being introduced at all filling stations, with gamma-ray units providing visual and audio precautions against over-filling on the powered chain-type conveyors used to guide the cylinders through the various processes. Engineers have also developed vacuum-pump equipment for evacuating returned cylinders and portable powered conveyors to speed up handling in the transport bays.

Oil-fired lime kiln

The first oil-fired lime kiln in the Peak District is being built for Beswick's Lime Works Ltd., a member of the Staveley Group of companies. The kiln is reported to have a unique method of firing. Instead of first 'cracking' the fuel in a separate combustion chamber and then feeding it into the kiln as a gas, the fuel will be gasified in the kiln itself. The entire steel casing for this kiln is 72 ft. high and in two sections, each over 25 ft. long and over 10 ft. diam., together weighing 17 tons.

African marketing agreement

A Johannesburg firm, Watermasters (Pty.) Ltd., is to produce and market, in South Africa, plant designed by William Boby & Co. The agreement between the two companies applies to the whole range of Boby water treatment equipment.

Vinyl acetate plant extension

Hedon Chemicals have recently completed substantial extensions to their vinyl acetate plant at Salt End, near Hull. The plant is situated on the 100-acre site owned by the Distillers Co. Ltd.'s Chemical Division. Hedon Chemicals is jointly owned by D.C.L. and Shawinigan Chemicals Ltd. of Canada. The vinyl acetate plant was initially commissioned in September 1956 and the recent expansion will increase the original productive capacity by approximately 60%.

Hydrogen plant extension

In 1958 the Power-Gas Corp. Ltd. completed a high-purity hydrogen plant at Warrington for Laporte Chemicals Ltd. The process was based on the continuous catalytic reforming of butane with steam and the plant formed part of their new hydrogen peroxide installation. The corporation are at present installing additional equipment to increase the production of hydrogen by 50% and it is planned to bring the extension into commission this summer.

Titanium oxide

Laporte Industries Ltd. have announced the formation of a company under the name of Laporte Titanium (Australia) Pty. Ltd., which is to manufacture titanium oxide at the £3½-million plant to be established at Bunbury, Western Australia.

Co-ordination of Swiss subsidiaries

Ciba Ltd. of Basle have formed a company in the U.K. with an authorised share capital of £3 million under the name of Ciba U.K. Ltd.

This company will act as the holding company for the Ciba interests in the U.K. by acquiring from Ciba Ltd., Basle, the issued share capital of its three wholly-owned U.K. subsidiary companies, namely Ciba Laboratories Ltd., manufacturers of pharmaceutical products, Ciba Clayton Ltd., a company selling dyestuffs, and Ciba (A.R.L.) Ltd., manufacturers of synthetic resins and adhesives, together with the controlling interest held by Ciba Ltd., Basle, in the Clayton Aniline Co. Ltd., manufacturers of dyestuffs.

It is intended that the new company will co-ordinate the activities of the Ciba group of companies trading in the U.K.

New premises

The technical service department of Laporte Titanium Ltd. have moved to their new premises at Harpenden, Herts. The laboratory is set in sufficient grounds to provide a site for an additional exposure station for testing the company's products, thus improving facilities for experimental investigations.

Phthalic anhydride plant

Grange Chemicals Ltd. announce that their new plant for the manufac-

A top platform section for the new N3 blast furnace for Ravenscraig works of Colvilles Ltd. in process of assembly in the Stockton works of Ashmore, Benson, Pease & Co. Ltd. Each of these furnaces has a hearth diameter of 25 ft. 9 in. and is designed to produce 1,000 tons/day of basic iron

ture of about 15,000 tons p.a. of phthalic anhydride will be built at Hull, adjacent to the Salt End chemical works of the Distillers Co. Ltd., who will operate it on behalf of Grange. The plant is expected to be commissioned during the second half of 1962, and the contract has been placed with Badger Ltd.

Pressure gauges and indexes

As a result of a sales agreement with the American Meter Co. Inc., U.S.A., Parkinson Cowan gas meters are now marketing in Great Britain the American company's volume and pressure gauges and base pressure and volume indexes.

Nylon-6 polymer

I.C.I. Ltd. and Emser Werke A.G./Inventa A.G. of Switzerland have concluded an agreement whereby I.C.I. has acquired rights for the technical information and patents relating to Emser Werke/Inventa's new processes for the manufacture of nylon-6 polymer and of caprolactam, upon which nylon-6 is based. Construction of plants will start shortly and production will commence early in 1963. Caprolactam will be made initially in a plant of 15,000 tons p.a. capacity to be erected on I.C.I.'s Severnside site. Concurrently a large-scale plant will also be built for the manufacture of nylon-6 polymer.

Courtaulds are also to build a nylon-6 plant with a capacity of between 20 million and 25 million lb. p.a. Under the process acquired last year from its associated Italian company, Snia Viscosa, the capacity of the plant will be 10,000 tons p.a. of caprolactam. Nylon made at present in this country is nylon-66, but nylon-6 is generally thought more suitable for industrial applications.

Heat exchangers

Alco Products Inc. has received two orders amounting to approximately $800,000 for a total of 75 heat exchangers to be manufactured at its plant here. The orders were placed by the Bechtel Corp., engineers and constructors, of San Francisco, California.

The larger order is for 47 heat exchangers to be used in a benzene plant which Bechtel is constructing for the Texaco Co. at Port Arthur, Texas.

The other order is for 28 heat exchangers to be used in a synthetic ammonia plant now under construction at Fort Madison, Iowa, for the California Chemical Co.

Isocyanate plant

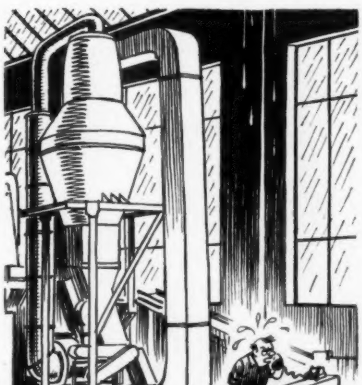
The second chemical plant to be erected by the Du Pont Co. (U.K.) Ltd. at Maydown, Northern Ireland, will produce isocyanates. The plant will cost several million pounds sterling and will be in operation in late 1963. The isocyanates will be sold to foam manufacturers. Du Pont have been selling isocyanates since 1944 and a large plant for making *Hylene* isocyanates was opened in the U.S. in 1956. In Britain the only manufacturer of isocyanates at present is I.C.I.

Fractionated distillation plant

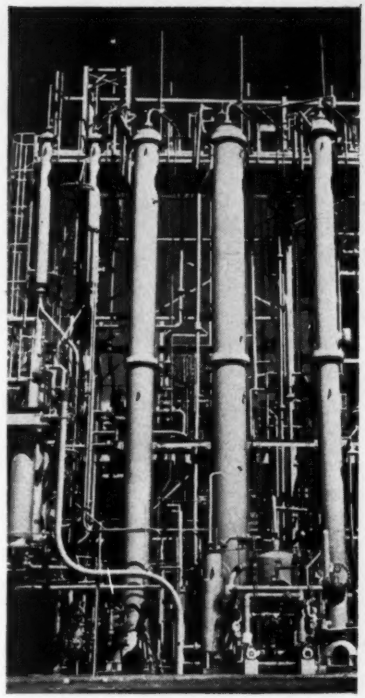
N.V. Chemische Fabriek 'Naarden' of Holland and Kemi Oy of Finland recently announced the signing of a preliminary agreement with Union Bag-Camp Paper Corp., U.S.A. Under its terms a jointly owned company will be set up under the name 'Naarden-Kemi' to build a fractionated distillation plant in Holland—the first of its kind within the European Common Market.

The plant is to be erected at Wormerveer, Holland, on a site owned by a subsidiary of 'Naarden' and about $1.7 million is involved. The new installation, which will be built along the lines of the tall oil distillation operation at Union-Camp's Savannah plant, is expected to come on stream in two years' time. N.V. Chemische Fabriek 'Naarden' will be responsible for running the new company and research and development projects will be carried out by both Union-Camp and 'Naarden'.

COMICAL ENGINEERING CORNER



"HELLO? — DRYING SHOP HERE"



Du Pont's £25-million capacity plant for the production of Hylene organic isocyanates, New Jersey, U.S.

First oil refinery

The New Zealand Oil Refining Co. have announced that they are planning to build the country's first oil refinery at Marsden Point, Whangarei. This site has many natural advantages. It has a safe deep-water harbour and thousands of level acres outside the earthquake zone.

Petrochemical works

Two refineries will be constructed in Sardinia. The first one, owned by Societa Algherese Industrie Chemiche Agricole, will have a yearly capacity of 1.2 million tons. It is planned, amongst other things, to obtain ethylene and propylene which will be used in adjacent petrochemical works. The second refinery, also with a yearly capacity of 1.2 million tons, is owned by Sarda Industrie Resine, who will also erect an adjacent petrochemical works.

Institute of Sewage Purification

At the annual conference of the Institute of Sewage Purification the newly-elected president, Mr. Martin Lovett, announced the election to fellowship of the following: Mr. A. L. Abbott, Mr. M. R. Vincent Daviss, Mr. E. Hodgson and Mr. W. Watson.

Orders and Contracts

Liquid methane

The Gas Council, Conch International Methane Ltd. and the French authorities responsible for the development of the Hassi R'Mel gas field in the Sahara have agreed on the terms of a contract under which liquid methane could be supplied from North Africa to Great Britain.

The scheme provides for the importation of approximately 350 million therms of liquid methane p.a. from Port Arzew to Canvey Island, and for its onward transmission in the first instance to seven Area Gas Boards. Two ships, each with a capacity of 11,000 tons of liquid methane, would transport the gas. Details have been forwarded to the Minister of Power for consideration.

Xylene as raw material

Grange Chemicals Ltd. is planning to erect a plant to manufacture about 15,000 tons p.a. of phthalic anhydride. Until recently this has been manufactured from naphthalene.

The raw material for the Grange operations would be ortho-xylene, which will be produced by a company, jointly owned by British Petroleum Co. Ltd. and California Chemical Co., in the plant to be built at B.P.'s Kent refinery.

Grange Chemicals is a subsidiary of British Hydrocarbon Chemicals Ltd., and a one-third interest is held by California Chemical Co. British Hydrocarbon Chemicals Ltd. is itself jointly owned by British Petroleum Co. Ltd. and the Distillers Co. Ltd.

Liquid purification plant

The chemical engineering division of W. C. Holmes & Co. Ltd. has received a further order for a Stretford liquid purification plant. This plant, to be supplied to the Northern Gas Board's West Hartlepool works, is designed for complete removal of hydrogen sulphide from 3 million cu.ft./day of coke oven gas.

The plant is scheduled to be in operation in May 1962. Arrangements are also being made to remove hydrogen cyanide from the gas prior to entering the main Stretford plant. This will reduce operating costs by preventing the formation of sodium thiocyanate in the washing solution.

Ammonia expansion

Nitrogen Fertilisers Ltd. have awarded a contract to Chemical Construction (G.B.) Ltd., covering the complete supply of a new synthetic ammonia plant. This will be located adjacent to an existing plant and will more than double the overall ammonia production capacity of Nitrogen Fertilisers Ltd. Raw material to be used consists of hydrocarbon gases originating from nearby steel mills, and the output of the new production unit will be delivered to Fisons Fertilizers Ltd. and West Norfolk Fertilizers Ltd. Completion of the project is expected in the latter part of 1962.

De-aeration plants

William Boby & Co. have been awarded two contracts by English Electric and one by Kellogg International Corporation for de-aeration plants. The first, worth £46,000, is for the supply of two de-aerators for Blyth B power station and the plants will each de-aerate 2,250,000 lb./hr. of feedwater. The second, worth about £150,000, is for the supply, delivery and erection of four large de-aerators, one for each of the 500-MW turbo-alternator sets which English Electric are building. The third is for the supply of a sodium-hydrogen blend and de-aeration plant for a new oil refinery in Pakistan. The equipment will have a capacity of 150 U.S. gal./min.

Iso-octanol transport

A fleet of 19 of I.C.I. Ltd.'s newest rail tank wagons, containing 300 tons of iso-octanol, recently formed a special train from the works of their heavy organic chemicals division at Billingham. Destined in the first place for King George V Dock, London, this plasticiser alcohol was shipped on the s.s. *Africa* to I.C.I. of Australia & New Zealand Ltd., Melbourne.

On arrival at King George V Dock, the liquid was pumped from the tank wagons into a tank on board the vessel by one of I.C.I.'s own pumping units.

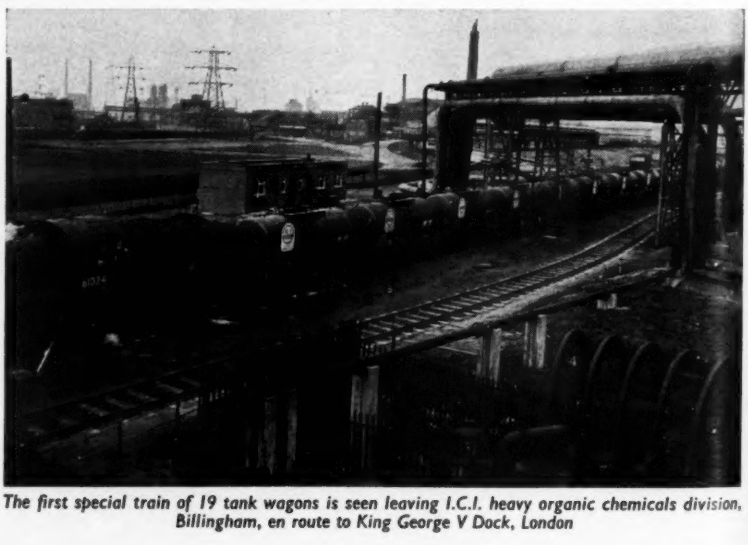
The new rail tank wagons are all fitted with the continuous vacuum brake so that the special trains, of which this was the first of a series, may travel at express speeds.

Fat-splitting plant

Price's (Bromborough) Ltd. have awarded a contract to Blaw Knox Chemical Engineering Co. Ltd. for the design, engineering, procurement of equipment and erection of a fat-splitting plant. This plant will employ the well-known *Colgate-Emery* process which uses high temperatures and pressures to achieve a high-degree split. It is expected that the plant will be completed near the end of this year.

Kwinana refinery expansion

B.P. have awarded a contract to Foster Wheeler Ltd. for the design, engineering, supply and construction of the process units required for the lubricating oil project at their Kwinana refinery. The process units to be sup-



The first special train of 19 tank wagons is seen leaving I.C.I. heavy organic chemicals division, Billingham, en route to King George V Dock, London

plied are a vacuum distillation unit, a furfural extraction unit, a M.E.K.-toluene dewaxing unit and a ferro-fining unit. Foster Wheeler Ltd. have formed an association with constructors John Brown Australia (Pty.) Ltd. for this contract. The new plant is expected to go on stream at the end of 1962, with an annual capacity of 100,000 tons of high-grade lubricants.

Water distillation plant

An order for an *Aquaflash* water distillation plant has been placed with Buckley & Taylor Ltd. by Hawthorn Leslie (Engineers) Ltd. on behalf of the B.P. Tanker Co. Ltd. The plant has been designed to operate on either low-pressure steam or water taken from a high-pressure boiler circulating system as a heat source for sea-water. It will be installed on a B.P. tanker and will be capable of producing 25 tons/day of fresh water from sea-water.

Antibiotics plant

Lightnin Mixers Ltd. have secured two orders for their fluid-mixing equipment from Italy. The first of these, for approximately £28,000 worth of mixers of all sizes, has now been fulfilled and the machines are being installed at the antibiotics plant of Fervet S.P.A. in Milan.

Urea process plant

The Power-Gas Corp. Ltd. has received a contract from Poland for a urea plant to produce 500 tons/day of prilled product for fertiliser use, including the production of a small proportion used directly as cattle feed.

This contract is valued at approximately £1½ million. The new plant will be the first of five to be built under the present five-year plan for Poland. Delivery of the plant will be effected in the early part of 1963.

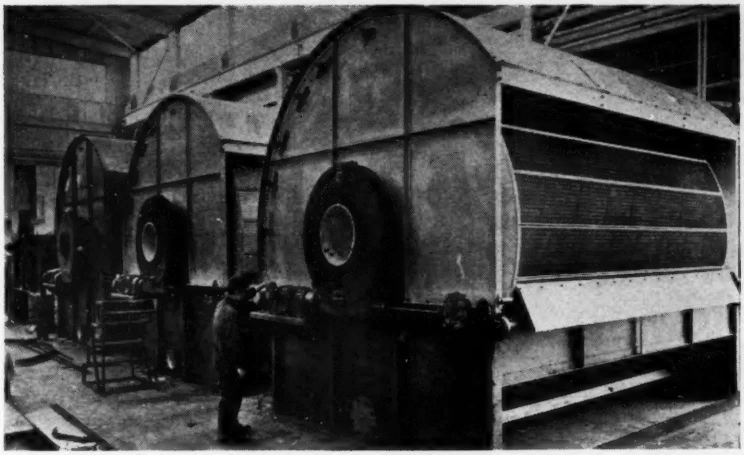
Demineralisation plant

Two contracts for demineralisation plant have been awarded to William Boby & Co. The Air Ministry has ordered equipment to demineralise water for use in jet aircraft during take-off. It is for the R.A.F. base at Gan in the Far East.

The other contract has been placed through Allen & Hanburys Ltd. and is for a plant at a factory manufacturing pharmaceutical products in Iran.

Blending plant

Blaw-Knox Chemical Engineering Co. Ltd. have been awarded a contract by J. C. Oxley's Dyes & Chemicals Ltd., a subsidiary of Williams (Hounslow) Ltd., to provide a plant for the blending of gas-oil.



These rotary vacuum filters under construction at the Gateshead works of Eimco (G.B.) Ltd. form part of a £140,000 export order for the U.S.S.R. Eimco is supplying the filtration equipment for two beet-sugar factories in the Ukraine

Vacuum flash evaporators

Richardsons, Westgarth & Co. Ltd. have received an order from the government of Curacao for two vacuum flash evaporators, each capable of producing 1,400,000 gal./day of drinking water. The order, which is worth approximately £500,000, is scheduled to be delivered in less than 12 months.

Danish refinery

The Gulf Eastern Co., an eastern hemisphere subsidiary of Gulf Oil Corp., have announced the award of the contract to build Gulf's first European refinery at Stigsnaes, Denmark, to Kellogg International Corp. The refinery will process 1½ million tons p.a. of crude oil from Gulf's supplies in eastern and western hemispheres.

Instrumentation for DRAGON

The U.K.A.E.A., acting on behalf of the O.E.E.C. Dragon Project, have awarded the contract for the design, supply and installation of the instrumentation of the high-temperature gas-cooled reactor being built at the Atomic Energy Establishment, Dorset, to Automatic Control Engineering Ltd. The contract is due for completion in December.

Manufacture of surface-active agents

Marchon Products Ltd. announce that their new plant in northern Italy, to be operated by their subsidiary, Marchon Italiana SpA., is now in production in Castiglione delle Stiviere (Mantova).

The plant has been designed for the manufacture of surface-active agents for industrial and cosmetic uses, for that sector of the Italian market.

Welding final lengths of pipe at Nahorkatiya in Upper Assam for the 720-mile-long crude-oil line which will connect Oil India's oilfields in Upper Assam to two new refineries in India

(Courtesy: Burmah Oil Co.

CPE World News

U.S.S.R.

Powder metallurgy plant

Specialists of Dniepropetrovsk, in the Ukraine, have prepared blueprints for a big powder metallurgy plant, the first of its kind in the Soviet Union.

The shops of the undertaking will occupy about 75 acres and will house equipment ensuring the all-round mechanisation and automation of all production processes. In the experimental shop, it is planned to install a three-stand rolling mill, designed by Ukrainian specialists, for the production of metal ceramic rolled stock. The basic raw material will be mill cinder—a by-product of rolling mills—and the plant will produce by the stamping and casting method various discs, bushings, turbine blades, gears and other articles which would not require any additional mechanical finishing. The plant is expected to go into production next year.

SWEDEN

Third largest plastics consumer

The production of plastics in Sweden has shown a four-fold increase over the past ten years and totalled 66,000 tons in 1960. A 10% increase is foreseen this year and, when the petrochemical establishments at Stenungsund, on the Swedish west coast, have come into operation in 1963, a further 20,000 tons will be added.

Sweden's consumption of plastics per head of the population is the third largest in the world after the U.S. and Western Germany and her *per capita* production of such products, the fifth largest.

AUSTRALIA

Synthetic rubber plant

The £5-million synthetic rubber plant of the Australian Synthetic Rubber Co. Ltd. is expected to begin production by September next. The Goodyear Tyre & Rubber Co. Ltd. holds a 30% interest in this company, with the other partner the Vacuum Oil Co. This new plant will have a rated capacity of 30,000 tons of dry polymer.

CZECHOSLOVAKIA

Iraqi contract

The Czechoslovak Foreign Trade Corporation Technoexport concluded a contract with the Iraqi Central Oil Refineries Administration for the supply of complete equipment of a factory for the manufacture of spare parts required by oil refineries. The plant will also make 60,000 propane-butane cylinders p.a.

The first deliveries and the construction of the factory will commence this year as soon as the drawing up of the complete projects has been completed. The factory will be put into operation by Czechoslovak experts.

RHODESIA

Nitrogen plant project

The Federal Government of Rhodesia has asked various interested companies to submit proposals for the establishment of a nitrogen plant in the Federation for the production of nitrogenous fertilisers and explosives.

ISRAEL

Natural gas pipeline

A 6-in. pipeline 29 km. long was recently completed in 125 working days at a cost of I£1.35 million bringing natural gas from the Rosh Zohar deposits to the Dead Sea potash works at Sodom, 1,000 m. below sea-level. The gas is stated to consist of 97.5% methane and 2.5% ethane. Fuel costs at the Dead Sea works will thus be cut drastically, as 130,000 tons of gas are to be piped in over the next three years.

SOUTH AFRICA

Titanium oxide plant

Brookhirst Igranic, a company in the Metal Industries Group, has received an order to supply control equipment for a new plant which has been engineered by W. J. Fraser and which is being erected by South African Titan Products in Umbogintwini. The plant is scheduled to produce titanium dioxide, which forms a basic chemical in the manufacture of paint and paper. The raw material used in making titanium dioxide is ilmenite, of which there are large deposits on the southern coast of Natal.

EGYPT

Suez refinery

The Compagnia Tecnica Industriale Petrolio of Rome has won the contract for a new large refinery at Suez. The Italian group will receive this contract for the engineering and construction for a value of approximately £9 million.

Russian visitors crowd round part of the I.C.I. Plastics Division display at the British Trade Fair, Moscow